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Water Quality Management Guidance for Mine-Related Pollution Sources (New, Current, and Abandoned)

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208 Program WQM Guidance Series

WATER QUALITY MANAGEMENT GUIDANCE FOR MINE-RELATED POLLUTION SOURCES

(New, Current, and Abandoned)

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Guidance information and direction is offered to State and local water quality management (WQM) agencies dealing with prevention and control of water pollution from new, current and/or abandoned mine-related pollution sources under the U.S. Environmental Protection Agency's 208 Program. Aspects of mine-related water Quality Management Plan development which are separately explained and discussed include water pollution source identification and assessment, current source control, identification and use of "Best Management Practices", abandoned source abatement, new source planning, and continuing water quality planning and management. Information presented includes mining regulatory control system features needed for effective water pollution prevention and control, basic mining water pollution control principles, and distinctions between point sources and nonpoint sources.

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SUBJECT: "Transmittal of Document Entitled "Water Quality Management Guidance for Mine-related Pollution Sources (New, Current and Abandoned)"

Walter S. Groszyk

FROM : Walter S. Groszyk, Deputy Director
Water Planning Division

TO : All Regional Water Division Directors
All 208 Coordinators
All Nonpoint Source Coordinators

TECHNICAL GUIDANCE MEMORANDUM - TECH 42

Purpose

Attached is a recently prepared guidance document that deals with water quality management in relation to new, current and abandoned mine-related water pollution sources. This guidance is intended to assist State and areawide WQM agencies to develop and to implement mine-related WQM programs that will be effective in preventing, controlling and abating pollution from new, current and abandoned mine-related point and nonpoint sources.

Guidance

This document is part of a series of guidance materials addressing WQM planning and implementation in each major nonpoint source pollution category. Other publications have or will soon be issued dealing with construction, hydrologic modifications, silviculture and agriculture.

These documents are provided in accordance with policies and procedures of 40 CFR, Part 131: "EPA will prepare guidelines concerning the development of water quality management plans to assist State and areawide (WQM) planning agencies in carrying out the provisions of these regulations".

This mine-related guidance separately discusses each of the major program thrusts which might be appropriately taken within mine-related WQM programs. These include: identification and assessment of existing current and abandoned sources; development and implementation of current source control systems; mine-related "Best Management Practices"; development and implementation of abandoned source pollution abatement programs; planning for prevention and control of pollution from new mine-related sources; and continuing water quality management and WQM planning.

Enclosure

EPA-440/3-77-027

WATER QUALITY MANAGEMENT GUIDANCE
FOR
MINE-RELATED POLLUTION SOURCES
(New, Current and Abandoned)

208 Water Quality Management Program

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Constructive review of early drafts of this mine-related WQM guidance by the following groups is acknowledged: U. S. D. I. Bureau of Mines; U. S. D. A. Soil Conservation Service; U. S. D. I. Fish and Wildlife Service; U. S. D. A. Forest Service; U. S. D. I. Bureau of Land Management; U. S. D. I. Geological Survey; various mine-related industrial trade associations; various national citizens' organizations; the Appalachian Regional Commission; selected State water pollution control agencies; representatives of mine-related industrial firms; selected State and designated areawide WQM agencies; and numerous officials within U. S. EPA Headquarters and its Regional Offices and research facilities.

SUMMARY

State and areawide water quality management (WQM) agencies are committed to achievement of "water quality that provides for the protection and propagation of fish, shellfish and wildlife and provides for recreation in and on the water . . . by July 1, 1983 . . ." under Public Law 92-500, "Federal Water Pollution Control Act Amendments of 1972".

Mine-related water quality management efforts undertaken by State or by designated areawide WQM agencies to achieve this water quality goal must deal with one or more of these five major program orientations:

1. Identification and assessment of existing current and abandoned sources;
2. Current source control, and identification and use of Best Management Practices or BMP's;
3. Abandoned source abatement;
4. New source planning; and
5. Continuing management and WQM planning.

This WQM guidance material discusses the pertinent issues and suggests work plan tasks and task sequences for addressing, in turn, each of these differing program orientations.

Recently enacted Federal coal mining legislation[1/] promises to be an effective implementation mechanism for prevention, control and abatement of pollution from new, current and abandoned coal mine-related sources. The abandoned mine reclamation, current mine regulatory control, hydrologic system protection, and mining unsuitability designation provisions of the new law, (which is to be administered by the U.S. Department of Interior) are consistent with this guidance, and should serve well the goals and objectives

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[1/] "Surface Mining Control and Reclamation Act of 1977," Public Law 95-87, August 3, 1977.

of the U.S. Environmental Protection Agency WQM program. Public Law 95-87 requires implementation of strong water pollution control in all coal States, provides Federal grant funds for State regulatory program development, partial Federal funding for control implementation and continuing enforcement costs, and establishes an Abandoned Mine Reclamation Fund. These provisions and requirements are so comprehensive that WQM agencies in coal States may increasingly focus more 208 Program effort on control of water pollution stemming from noncoal mineral industrial operations.

Mine-related water pollution includes all point and nonpoint source pollutant contributions to receiving surface waters and ground waters, resulting from mineral exploration, mine development, mineral extraction, mineral processing, mineral transport, mineral storage and mineral waste disposal. The example of mine-site hydrologic examination contained in Appendix A will be found useful for understanding distinctions between point sources and nonpoint sources as they are currently defined under the National Pollutant Discharge Elimination System. Mine-related WQM program efforts should be defined in response to recognized management and control system needs.

Identification and assessment should determine which contributing current and abandoned mine-related pollution sources, and the extent to which such sources, interfere with achievement of water quality goals and with protection of beneficial water uses.

State and areawide WQM agencies must assure that the necessary institutional arrangements, management programs and control systems are established to achieve water quality goals and to protect beneficial water uses.

Mine dewatering and mineral processing waste water discharges from current operations are controlled as point sources either directly by the Federal government (U.S. EPA) or through approved State regulatory control programs under the National Pollutant Discharge Elimination System (NPDES); nonpoint sources of water pollution associated with all phases of current mine-related industrial operations are to be controlled through the use of Best Management Practices or BMP's. WQM agencies may not be directly involved in design and application of the specific details of preventive measures and control practices or BMP''s at individual mineral industrial operations sites. This is so because the mining industry will often play the biggest part in designing the specific details of preventive measures and control practices for use at each site. The responsibility of WQM agencies lies rather in seeing to it that a regulatory process is established which is effective in identifying "Best Management Practices" for each mine-related operation, and that those preventive measures and control practices which are identified are also in fact utilized.

With respect to abandoned mine-related sources, the legal, institutional and financial arrangements required for implementation of water pollution abatement programs hold the key to success more often than supporting engineering and water quality data. Abandoned mine program efforts must emphasize direct abatement of water pollution, but must be integrated with other objectives, such as aesthetics, land productivity restoration, economic development, public safety, etc., if programs are to gain adequate political support.

WQM planning for new mine-related sources involves identification of potential contributing sources, assessment of future pollutant impacts on receiving surface water and ground water quality goals and beneficial uses, and development of management and control system strategies designed to achieve effective prevention and control.

Continuing management and WQM planning processes are to be developed which provide effective on-going control of mine-related sources, anticipate and deal with new source prevention and control needs, and coordinate mine-related management and control systems with all other aspects of the overall WQM program.

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CHAPTER 1.0

A WQM PROGRAM FOR MINE-RELATED SOURCES

1.1 Requirements and Definitions

1.1.1 Requirements

Section 201(c) of Public Law 92-500, "Federal Water Pollution Control Act Amendments of 1972," requires that "To the extent practicable, waste treatment management shall be on an areawide basis and provide control or treatment of all point and nonpoint sources of pollution, including in place or accumulated pollution sources."

Section 208(b)(2)(G) states that "Any [208] plan prepared under [a continuing State or areawide waste treatment management planning process] shall include, but not be limited to, a process to identify, if appropriate, mine-related sources of pollution, including new current and abandoned surface and underground mine runoff, and set forth procedures and methods (including land use requirements) to control to the extent feasible such sources."

Each State or designated areawide water quality management agency will formulate a work program for mine-related pollution source identification and control. These programs will vary in level of detail, in content and in timing according to local conditions, such as:

1. The characteristics of past, present and future mine-related industrial activities;
2. The water pollution impact potential of mine-related sources; and
3. The features and effectiveness of any existing control system(s).

Initially, State and areawide WQM agencies must judge whether mine-related sources of water pollution within each of their planning jurisdictions deserve attention as a part of their water quality management planning process.

Mineral industrial operations take place within all fifty States. Because of the nature and characteristics of mining and associated mineral industrial operations, potential surface water and/or ground water pollution contributions (principally in the forms of sedimentation and mineralization) should normally be expected. Unless there is definite proof that mine-related operations do not in any way adversely affect protection and propagtion of fish, shellfish and wildlife, or other beneficial water uses, mine-related sources of water pollution and hydrologic impacts should be examined within the framework of WQM programs in every State.

1.1.2 Definitions

Point Source -- a mine-related point source is "any discernable, confined, and discrete conveyance, including but not limited to any pipe, channel, ditch, tunnel, conduit, well, discrete fissure (or) container . from which pollutants are or may be discharged," from any mine-related area or facility under the effluent guidelines and other applicable provisions of a National Pollutant Discharge Elimination System (NPDES) permit. The applicability of federal point source effluent limitations to mine-related discharges is addressed in effluent guidelines and standards rules and regulations published in the Federal Register by the U. S Environmental Protection Agency (EPA).

Nonpoint Source -- a mine-related nonpoint source is a contributing source resulting from mineral industrial activity which causes surface water and/or ground water pollution beyond those point source pollutant discharges which are specifically controlled by NPDES permit. Mine-related nonpoint sources (not controlled by NPDES permit) include all pollutant contributions other than NPDES discharges from active, inactive and abandoned surface and underground mine sites, mine spoils, mine haul roads, mineral exploration operations, mineral transport systems, mineral processing, storage, waste disposal and other affected areas. Also included are surface areas, ground water and hydrologic systems affected by underground mining.

Best Management Practices -- a Best Management Practice (BMP) is defined in EPA's "Guidance for State and Areawide Water Quality Management Program Development" (November 1976), as:

> "... a practice, or combination of practices, that is determined by a State (or designated areawide planning agency) after problem assessment, examination of alternative practices, and appropriate public participation to be the most effective, practicable (including technological, economic, and institutional considerations) means of preventing or reducing the amount of pollution generated by nonpoint sources to a level compatible with water quality goals."

Identification -- the recognition of specific mine-related sites or classes of mine-related sites as contributing sources or potentially contributing sources of water pollution and/or hydrologic system disturbance.

Assessment -- the act of determining the effects or impacts of mine-related pollutant contributions and hydrologic system disturbances from identified mine sites or mine-related source subcategories on achievement of water quality goals and protection of beneficial water uses.

Mine-related Source Subcategory -- a group or class of sites or sources of mineral industrial operations defined for convenience in conducting WQM work.

National Water Quality Goal -- Section 101 of Public Law 92-500 identifies the national goal as "water quality that provides for the protection and propagation of fish, shellfish, and wildlife and provides for recreation in and on the water ... by July 1, 1983 ...."

1.2 Commercially Mined Minerals

Commercially mined mineral commodities may be classified and described according to any of a number of different mineral classification systems. The minerals list in Table 1.1 is based with minor modifications on Standard Industrial Codes (SIC).

Each of these mineral commodities occurs under a differing range of geologic, hydrologic, climatic and surface topographic conditions. Separate point source effluent discharge guidelines (including in some cases "zero discharge" requirements) have been proposed or adopted as NPDES requirements for control of mine dewatering and process waste water discharges associated with mining and milling or processing of all commercially extracted minerals which produce confined point source waste water discharges. NPDES discharge limitations for point sources in each mineral subcategory are applicable to mineral industrial operations in all States.

Nonpoint source controls may similarly be needed to prevent or to control other forms of surface water and/or ground water pollution from areas affected by operations associated with all commercially mined minerals.

1.3 Mine-related Pollutants

Specific pollutants associated with mining, milling and processing of each mineral commodity may be identified generally from EPA's effluent guidelines development documents. For greater detail, identification can be made from various mine-related water pollution reports and research studies, Federal, State, local and industrial water quality records and experienced experts.

Table 1.1 - Classification of Commercially Mined Minerals

1. Mineral Fuels and Carbonaceous Minerals

- Anthracite Coal
- Bituminous Coal
- Sub-Bituminous Coal
- Lignite
- Natural Gas
- Geothermal Energy
- Petroleum
- Oil Shale
- Tar Sands
- Peat
- Carbon Dioxide

2. Metallic Minerals

- Iron
- Copper
- Lead
- Zinc
- Gold
- Silver
- Bauxite
- Ferroalloys
- Cobalt, Columbium, Managanese, Nickel
- Chromium, Tantalum, Molybdenum, Tungsten
- Mercury
- Antimony
- Beryllium
- Platinum
- Tin
- Titanium
- Rare Earth (elements 39 and 57-71)
- Zirconium
- Uranium
- Radium
- Vanadium

3. Nonmetallic Minerals

a. Dimension stone

- Granite
- Quartz
- Dolomite
- Slate
- Limestone
- Quartzite
- Marble
- Sandstone

b. Crush stone

- Calcareous Marl
- Granite
- Traprock
- Marble
- Sandstone
- Limestone
- Dolomite
- Shells
- Quartzite
- Quartz

c. Sand and gravel (construction)

d. Industrial sand

e. Asphaltic minerals

- Bituminous limestone
- Oil impregnated diatomite
- Gilsonite

f. Other nonmetallic minerals

- Asbestos
- Wollastonite
- Lightweight aggregate minerals
  - Perlite
  - Pumice
  - Vermiculite
- Mica
- Sericite
- Barite
- Fluorspar
- Salines
- Borates
- Potash
- Trona ore
- Phosphate rock
- Rock salt
- Sulfur (Frasch)
- Mineral pigments
- Lithium minerals
- Sodium sulphate
- Bentonite
- Fill and base materials
- Fire Clay
- Fuller's earth
  - Attapulgite
  - Montmorillonite
- Kaolin
- Ball Clay
- Feldspar
- Kyanite
- Magnesite (naturally occurring)
- Shale and other clay minerals
  - Shale
  - Aplite
- Talc
- Soapstone
- Pyrophyllite
- Steatite
- Natural abrasives
  - Garnet
  - Tripoli
- Diatomite
- Graphite
- Miscellaneous nonmetallic minerals
  - Jade
  - Novaculite
- Top soil

Stream parameters and specific pollutants that have been monitored in association with control of mine-related water pollution include:

- Surface water flow
- Ground water movement
- Temperature
- pH
- Acidity
- Alkalinity
- Dissolved oxygen (DO)
- Turbidity
- Total suspended solids (TSS)
- Total dissolved solids (TDS)
- Sulphates
- Hardness (cations except alkali metals)
- Chemical oxygen demand (COD)
- Specific conductance
- Salts
- Metals (most widely monitored)
  - Iron
  - Aluminum
  - Manganese
  - Zinc

Contaminants which have been monitored to a lesser extent include: copper, cobalt, nickel, arsenic, lead, mercury, cadmium, chromium, sulfur, uranium, cyanide, antimony, ammonia, radium 226, fluoride, phosphate, phenol, nitrogen, and molybdenum.

Aquatic biological criteria relate more directly to the water quality goal and impacts on goal achievement than do chemical parameters. Alternative biological field study methodologies are described in "Biological Field and Laboratory Methods for Measuring the Quality of Surface Waters and Effluents", EPA 670/4-73-001, July 1973.

Each mineral that is mined, milled or processed within each State or local area will be characterized by its own particular set of potential surface water and/or ground water pollutants. Asbestos fibers, radioactive contaminants, fugitive dust, or thermal pollution may present problems in some areas. Amendments (fertilizers, etc.) applied for revegetation and final reclamation on some surface mine sites, as well as milling and processing reagents, may expand the list of pollutant parameters to include BOD, nitrates, and others dependent upon specific conditions and amendment and reagent constituents. Chemical properties of mineral deposits closely associated with each mineral mined in each locale will also directly influence the types of pollutants which may be present.

1.4 Mine-related Pollution Sources

Contributing mine-related point and/or nonpoint sources of water pollution can occur at the majority of sites affected by each of the phases of mineral industrial operations. These phases include mineral exploration, mine development, mineral extraction, mineral transport, mineral milling and processing, mineral product storage and mineral waste disposal. Minerals that were mined in other States or imported from overseas may be processed in a local area. Secondary transport of mineral products from primary storage areas to final users, or to raw material storage areas, may produce water pollution contributions similar to those associated with mine-related sources. However, these contributions may be more logically treated as a part of the examination of each of the various user industrial categories, such as coke, steel, utilities, cement, fertilizers, brick, etc. Regardless of where the lines of distinction are drawn between mine-related and user industry pollution contributions, Section 201(c) of Public Law 92-500 which instructs WQM agencies to provide for "control or treatment of all point and nonpoint sources of pollution" will remain applicable and will be unaffected by the definitions of categories. Table 1.2 contains a list of the types of pollution source areas associated with each of the phases of mineral industrial operations.

1.5 General Forms of Mine-related Water Pollution

Water pollution from mine-related sources includes all discharges controlled by NPDES permit, as well as other surface water and ground water pollutant contributions which result from mineral exploration, mine development, mineral extraction, processing, transport, storage

Table 1.2 - Mine-related Pollution Source Areas by Phase of Operation

Phase of mineral industrial operation	Mine-related pollution source areas	Deposit/source description
Exploration phase	Exploration sites (drill pads, excavations, etc.)	
Development phase	Mine development	Roads, shafts, facilities, wells, etc.
Extraction phase[1/]	Open pit mine (rock quarries, copper, iron, etc.)	Thick, concentrated deposits, usually supporting long duration operations, above or below ground water level
	Deep mine (mostly metallic)	Irregular and vein deposits, above or below ground water level
	Deep mine (coal, etc.)	Extensive continuous bed deposits, above or below ground water level
	Strip mine (clay, sand and gravel, etc.)	Irregularly occurring, exposed, or shallowly overburdened deposit
	Strip mine (coal, phosphate etc.)	Extensive overburdened bed deposit above or below ground water level
	Mineral extraction wells	Petroleum, natural gas, brine, geothermal, leaching and solution mining wells
Transportation phase	Mineral transportation systems (including loading/receiving areas)	Mine haul roads, pipelines, conveyors, truck, rail and barge transport systems
Processing phase	Ancillary milling and processing plant areas	Screening, crushing, washing and concentration, and benefaction operations
Waste disposal phase	Mineral waste disposal areas	Refuse and tailings piles, tailings ponds, slime ponds, injection wells, etc.
Storage phase	Crude and processed mineral storage areas	Temporary or long term storage sites at processing area or at raw material storage area near user manufacturing/industrial/utility site

1/ Open pit mining, deep mining, strip mining and well extraction are listed as examples (there are also a number of important variations of each of these methods). Other forms or methods of mining not listed include placer mining, hydraulic mining, in-situ leaching and combustion, auger mining, and geothermal energy extraction.

and waste disposal. Mine-related point sources include milling and processing plant waste water discharges (processing phase) and mine dewatering discharges (extraction phase). Mine-related nonpoint sources on the other hand can be associated with any or all phases of mineral industrial operations.

The characteristics of specific nonpoint sources will be determined by the manner of interaction of the mine-related operations with internal and the surrounding external hydrologic systems. The types of pollutants and modes or circumstances of transfer will be related to the mineral being mined, the associated beds being disturbed, the specific methods of mining, and associated processing, transport, storage and waste disposal. Some of the various forms of mine-related nonpoint water pollution are:

1. Suspended solids carried by immediate surface runoff;
2. Dissolved solids carried by immediate surface runoff;
3. Suspended and dissolved solids in proximate subsurface water seepage;
4. Dissolved solids in ground water recharge;
5. Dissolved solids in ground water discharge;
6. Uncontrolled contributions from mine-related point sources:
    a. High instantaneous concentrations of regulated pollutants in excess of effluent discharge guidelines, but falling within the NPDES instantaneous and daily average discharge limitations;
    b. Unregulated minor contaminants in point source discharges which are not specifically included under NPDES effluent limitations;

   c. Untreated mine dewatering discharges during or following major storm events (NPDES point source treatment systems may be bypassed during storm events of greater than a 10-year, 24-hour intensity);

7. Reclaimed mine area and undisturbed area drainage diversion discharges; and
8. Surface water and ground water contamination and degradation induced by mine-related hydrologic disturbances and imbalances. Some examples of mine-caused hydrologic disturbances are: modification of surface water flow regimes downstream from mineral industrial operations; increased or decreased ground water recharge; lowering of ground water levels as a result of mine dewatering; reduction of base flow in surface water courses; and inducement of salt water intrusion or interaquifer flows resulting in fresh water aquifer contamination. Hydrologic modifications can not only degrade surface water and ground water quality but may produce damaging modifications to aquatic habitats of fish, shellfish and wildlife.

1.6 Focusing WQM Work on Control/Management System Needs

Mine-related water pollution control and management system needs must be recognized before the work plan is formulated if WQM efforts are to focus on the most appropriate issues. Control and management system needs and associated WQM requirements will depend upon:

1. The characteristics of past, present, and future mineral industrial operations within the planning area;

2. The water pollution impact and impact potential of contributing mine-related pollution sources on achievement of water quality goals and protection of beneficial water uses;
3. The accomplishments of past and continuing mine-related WQM efforts; and specifically
4. The adequacy and effectiveness of established regulatory control systems and pollution abatement programs.

1.6.1 WQM Advisory Committees

WQM advisory committees should be used to determine the most appropriate focus for the initial mine-related WQM work plan. EPA's "Public Participation Handbook for Water Quality Management" (June 1976), and "Working Effectively with Advisory Committees in Water Quality Planning" (May 1977), suggest an organizational structure for advisory committees. A properly constituted Mine-related Water Pollution Committee or a general committee (such as a Nonpoint Pollution Committee) consisting of mining agency and industry representatives should be able to identify and examine existing information and recommend the most appropriate orientation for the mine-related WQM work plan. The advisory committee approach also will insure that the content and timing of mine-related WQM efforts are consistent with all other aspects of the overall WQM program in each State or local area. Mine-related WQM objectives should be consistent with and supportive of the wildlife management plans, programs and goals of agencies of each of the levels of government operating within the State or local planning jurisdiction.

Representatives from the following groups could serve on a mine-related advisory committee:

1. State Government:

   - Geologic Survey
   - Bureau of Mines
   - Division of Reclamation
   - Water Pollution Control (mining)
   - Solid Waste Management (mining)
   - Fish and Game Department
   - Abandoned Mine Abatement Program Office

2. Industry:

   - Mining Industrial Trade Associations
   - Mining Companies
   - Mining Industrial Services Companies
   - Mineral-using Industrial Firms

3. Federal Government:

   - U. S. Department of Interior
   - U. S. D. I. Office of Surface Mining Reclamation and Enforcement
   - U. S. D. I. Geological Survey
   - U. S D. I. Bureau of Mines
   - U. S. D. I. Fish and Wildlife Service
   - U S. D. I. Bureau of Land Management
   - U. S. D. I. National Park Service
   - U. S. D. I. Mining Enforcement and Safety Administration
   - U. S. D. A. Forest Service
   - U. S. D. A. Soil Conservation Service
   - Energy Research and Development Administration
   - Department of Defense Land Management Offices
   - Nuclear Regulatory Commission
   - Army Corps of Engineers

1. 6. 2 WQM Program Areas

Mine-related WQM work can be classified into several program areas, each of which is discussed separately within other chapters of this guidance:

1. Existing source identification and assessment (Chapter 2);
2. Current source control system development (Chapter 3);
3. Identification of BMP's in a control system context (Chapter 4);
4. Abandoned source pollution abatement program development (Chapter 5);

5. New source identification, assessment, and control strategy formulation (Chapter 6); and
6. Continuing water quality management and WQM planning process development (Chapter 7).

The advisory committee(s) should be charged with the task of sifting through existing data bearing on abandoned, current and new mines, mine-related operations, and mine-related water pollution. The committee(s) should set priorities for WQM efforts among the various mine-related WQM program areas.

In advance of decisions regarding work plan orientation an examination of mine-related control and management system needs should provide appropriate responses to the following series of questions:

- How much effort within the WQM program should be focussed on identifying existing mine-related contributing sources (current and abandoned) and assessing their impacts on surface water and ground water quality and water quality goal achievement and beneficial use protection?
- How much relative emphasis should be given to current source vs abandoned source WQM program orientations?
- How complete and effective in preventing and controlling water pollution from all contributing point and nonpoint sources is any existing regulatory control system?

  It may be particularly difficult for a WQM agency to obtain an objective answer to questions of control system effectiveness, especially if the WQM agency is itself a part of the government organization which administers the control program. Both mine-related regulatory control authorities and representatives of regulated industries may be reluctant to admit to control system deficiencies or to recommend any critical examination of existing control system effectiveness as a part of the WQM program.

- Are the most effective of available preventive measures and control practices (BMP's) being identified and used to prevent and control water pollution from all contributing mine-related sources?
- Is there any established pollution abatement program for abandoned mines which could be used to achieve water quality goals defined through the WQM program?
- How much WQM program effort should be focused on new sources of water pollution from future mineral industrial operations?
- What emphasis and importance should be attached to development of an effective continuing water quality management process and an ongoing WQM planning program?

Chapters 2 through 7 deal with each of the major mine-related WQM program orientations (i.e. existing source identification and assessment, current sources, abandoned sources, new sources, etc.). Important aspects of WQM are identified, pertinent issues are discussed, and, where appropriate, work plan tasks and task sequences are suggested.

CHAPTER 2.0

EXISTING SOURCE IDENTIFICATION AND ASSESSMENT

2.1 Purpose

The primary purpose for conducting an identification and assessment (I and A) of existing currently active, inactive and abandoned sources in association with a State or areawide WQM program is to place the impacts from various mine-related water pollution sources in proper perspective on an areawide basis with one another and with the impacts of pollutants from all other categories of contributing sources (municipal, industrial, agricultural, silvicultural, construction, urban, etc.).

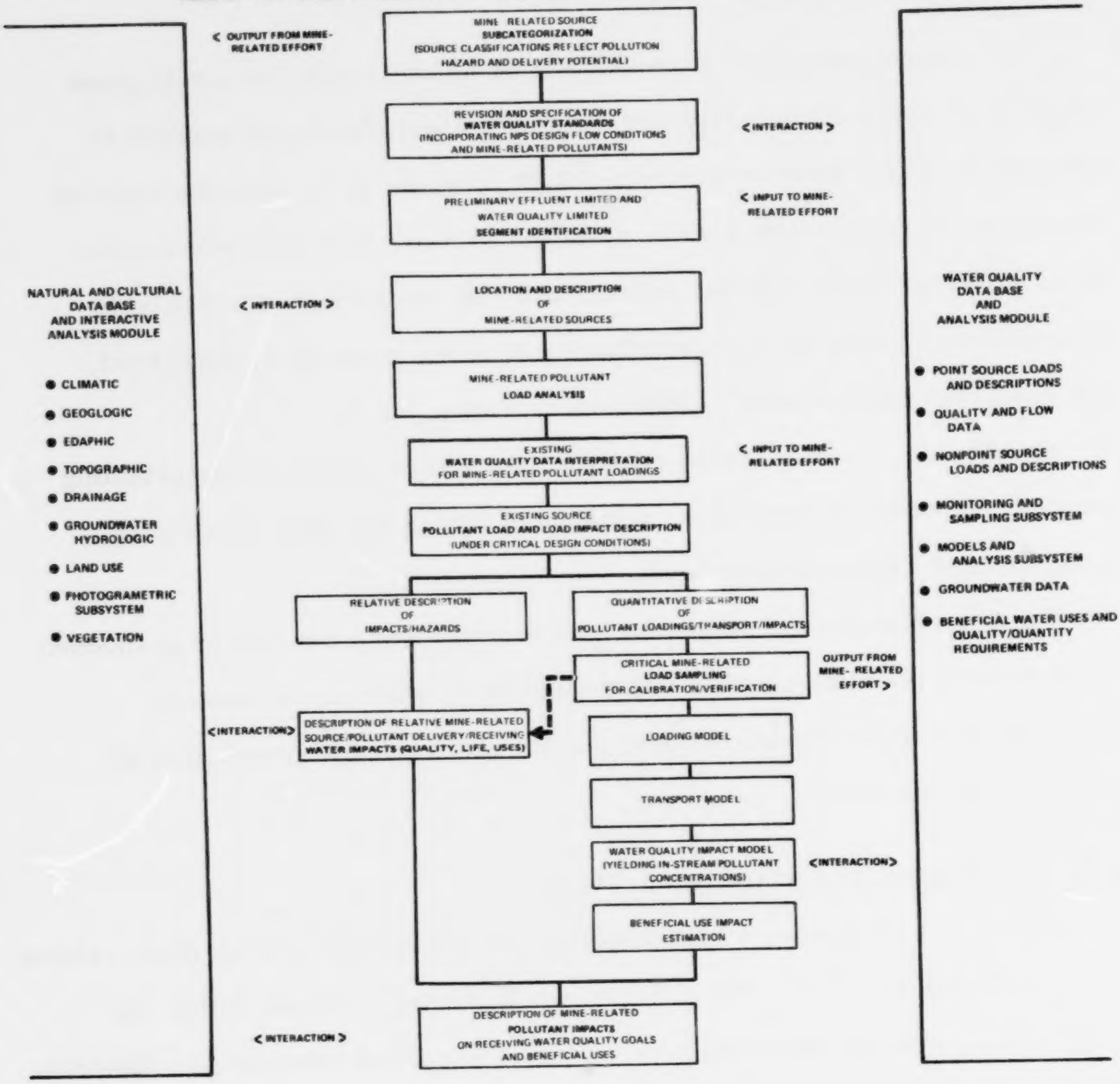
In addition, I and A should produce information useful for determining the most appropriate emphasis, detail, and timing for other aspects of mine-related WQM program work.

I and A effort should determine which contributing current or abandoned mine-related pollution sources and the extent to which these sources interfere with achievement of water quality goals and with protection of beneficial water uses.

2.2 Identification and Assessment Tasks

Figure 2.1 illustrates a task sequence for I and A of existing mine-related water pollution sources. The general task sequence is shown within the larger framework of other WQM data bases and analysis modules to illustrate that mine-related WQM tasks are never performed in isolation from other aspects of State and areawide WQM programs.

FIGURE 2.1— TASK OUTLINE FOR IDENTIFICATION AND ASSESSMENT OF EXISTING MINE—RELATED POLLUTION SOURCES


NATURAL AND CULTURAL DATA BASE AND INTERACTIVE ANALYSIS MODULE
● CLIMATIC
● GEOGLOGIC
● EDAPHIC
● TOPOGRAPHIC
● DRAINAGE
● GROUNDWATER HYDROLOGIC
● LAND USE
● PHOTOGRAMETRIC SUBSYSTEM
● VEGETATION
< OUTPUT FROM MINE-RELATED EFFORT
MINE RELATED SOURCE SUBCATEGORIZATION (SOURCE CLASSIFICATIONS REFLECT POLLUTION HAZARD AND DELIVERY POTENTIAL)
REVISION AND SPECIFICATION OF WATER QUALITY STANDARDS (INCORPORATING NPS DESIGN FLOW CONDITIONS AND MINE-RELATED POLLUTANTS)
< INTERACTION >
PRELIMINARY EFFLUENT LIMITED AND WATER QUALITY LIMITED SEGMENT IDENTIFICATION
< INPUT TO MINE-RELATED EFFORT
< INTERACTION >
LOCATION AND DESCRIPTION OF MINE-RELATED SOURCES
MINE-RELATED POLLUTANT LOAD ANALYSIS
EXISTING WATER QUALITY DATA INTERPRETATION FOR MINE-RELATED POLLUTANT LOADINGS
< INPUT TO MINE-RELATED EFFORT
EXISTING SOURCE POLLUTANT LOAD AND LOAD IMPACT DESCRIPTION (UNDER CRITICAL DESIGN CONDITIONS)
RELATIVE DESCRIPTION OF IMPACTS/HAZARDS
QUANTITATIVE DESCRIPTION OF POLLUTANT LOADINGS/TRANSPORT/IMPACTS
CRITICAL MINE-RELATED LOAD SAMPLING FOR CALIBRATION/VERIFICATION
OUTPUT FROM MINE- RELATED EFFORT >
<INTERACTION>
DESCRIPTION OF RELATIVE MINE-RELATED SOURCE/POLLUTANT DELIVERY/RECEIVING WATER IMPACTS (QUALITY, LIFE, USES)
LOADING MODEL
TRANSPORT MODEL
WATER QUALITY IMPACT MODEL (YIELDING IN-STREAM POLLUTANT CONCENTRATIONS)
<INTERACTION>
BENEFICIAL USE IMPACT ESTIMATION
< INTERACTION >
DESCRIPTION OF MINE-RELATED POLLUTANT IMPACTS ON RECEIVING WATER QUALITY GOALS AND BENEFICIAL USES
WATER QUALITY DATA BASE AND ANALYSIS MODULE
● POINT SOURCE LOADS AND DESCRIPTIONS
● QUALITY AND FLOW DATA
● NONPOINT SOURCE LOADS AND DESCRIPTIONS
● MONITORING AND SAMPLING SUBSYSTEM
● MODELS AND ANALYSIS SUBSYSTEM
● GROUNDWATER DATA
● BENEFICIAL WATER USES AND QUALITY/QUANTITY REQUIREMENTS

Mine-related I and A can use information from the larger water quality data base and the larger natural and cultural information base which routinely must be prepared as a part of every WQM program. Mine-related WQM efforts may also produce outputs which can be usefully input into, and integrated with, other phases of the overall WQM effort. For example, estimates of mine-related sediment loadings could be put into the larger water quality data base, and integrated and compared with sediment loadings estimates from agricultural sources, silvicultural sources, construction sources, etc.

2.2.1 Subcategorization of Mine-related Sources

Mine-related pollution sources should be subcategorized (classified) according to similarities in pollution hazard and risk potential and specific types of pollutants generated. Distinctions normally should be made among mine-related operations involving different mineral commodities, except in those cases where the pollutants generated are the same or very similar in composition, range of concentration, and mechanisms of delivery. Separate subcategories will usually be recognized for abandoned sources, inactive sources, and active sources; in addition to deep mine sources, surface mine sources, well extraction sources, mineral processing sources, mineral transport sources (roads, railroads, etc.), mineral storage sources, and mineral waste disposal site sources.

Subcategories may be established for convenience in dealing with institutional as well as with technical distinctions among sources. For example, active metallic mines on Federal lands could be classified separately from active mines on State or on private property.

Most mineral industrial operations sites will contribute pollutants to surface and/or ground waters through nonpoint source mechanisms. Even those mineral extraction and processing sites which are characterized by mine dewatering and process waste water point source discharges, controlled under NPDES permits, will often contribute pollutants simultaneously through nonpoint source mechanisms.

When recognition of numerous mine source subcategories becomes too difficult some groups can be merged into a smaller number of combined classes.

In some cases, the pollutant impact from particular mine source subcategories on surface water and ground water quality and beneficial uses may be only suspected or poorly understood and ill-defined. Under these circumstances, research efforts can be conducted on a limited scale into the nature and extent of water pollution impacts, with emphasis on developing information needed to design effective controls.

I and A must show WQM personnel whether water pollutant contributions from a suspected source(s) interferes with achievement of water quality goals. For example, a University of Missouri study team suspected the occurrence of high concentrations of trace metals along both active and inactive vehicular transport routes. These routes were used to haul lead sulfide concentrate in open trucks from lead mine/mill complexes to smelters in southeastern Missouri. The study team later concluded that "the transportation of lead ore can contribute very markedly to the contamination of the environment and measures should be taken to reduce this source of contamination to a minimum.[1]

A matrix cross index classification approach frequently has been used to make distinctions in mine-related source impact potential. Under this system basic mine source subcategories can be further subdivided to reflect variations in specific site conditions and characteristics known to be closely associated with pollution hazard and risk potential. These include chemical properties of geologic strata, percent slope, type and degree of revegetation, proximity to receiving stream, relation to ground water recharge zones, etc.

Appropriate consideration should be given to the practical problems of source identification and class distinction. The numbers and locations of sources in some classes which are particularly difficult to locate and distinguish could be estimated, unless judged to be of extreme individual importance to the WQM effort. This could be true especially of abandoned deep mines, where records of portal locations and extent of workings do not exist.

2.2.2 Revision of Water Quality Standards

WQM agencies in every State are responsible for evaluating and revising Water Quality Standards every three years. EPA's "Quality Criteria for Water" (EPA-440/9-76-023) has been made available to the States for guidance in developing their Water Quality Standards. They should incorporate all mine-related pollutants to protect beneficial water

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1/ Wixson, Bobby G., Jennett, Charles J., et.al. "An Interdisciplinary Investigation of Environmental Pollution by Lead and Other Heavy Metals from Industrial Development in the New Lead Belt of Southeastern Missouri." p. 357, Volume I. Interim Report for the Period May 1972 to June 1974. University of Missouri. June 1974.

uses from mine-related pollutant impacts. As protected uses, each drainage segment may include water supply, propagation of fish, shellfish and wildlife, water recreation and agricultural, industrial and other specific use categories. Revised water quality standards could include stochastic criteria for runoff-related nonpoint source contributions, development of high flow criteria, seasonally variable standards, and biological standards, including bioassay criteria.

The standards established should take into account stream biology and sensitivity of aquatic life, benthic deposit transport and resuspension impacts, and additive or synergistic and cumulative pollutant impacts, as well as locally critical design flow conditions. Critical design conditions should represent flow conditions of greatest potential stress to fish, shellfish and other aquatic life; the traditionally used low flow/high temperature conditions may not represent the design state of greatest stress, particularly from runoff-related nonpoint sources. As an example, stream sampling during rainstorms on streams affected by lead mining and milling in south-eastern Missouri showed that peak concentrations of lead, cadmium, zinc and copper occurred during the peak runoff period. This implied that large masses of mine-related pollutants were being carried in runoff during heavy storms.[2] Where instantaneous in-stream pollutant levels may not be objectionable, cummulative effects on aquatic life may justify efforts to prevent or control even low-level pollutant contributions. Most of the commonly monitored pollutants associated with mining, milling, and processing of domesticly produced mineral commodities were listed earlier in Chapter 1.0, Section 1.2.

2/ Ibid. p. 231

2.2.3 Segment Identification

Data pertaining to identified effluent limited and water quality limited drainage segments should be obtained from the larger water quality data base referred to earlier in Figure 2.1. Any total nonpoint source load estimates and mine-related point source load estimates already available should be used. Areas of mine-related point and nonpoint source water pollution impact, indicated from segment classification data, can be used in mine-related source identification, location and impact description efforts. Where general segment classification data is not already available, water quality limited and effluent limited segments can be identified in connection with subsequent mine-related source location and description, existing water quality data interpretation and water quality and beneficial use impact estimation efforts.

2.2.4 Location and Description of Potentially Contributing Mine-Related Sources

Identification Methodology

The method chosen for identifying mine-related pollution sources through location and description must be appropriately suited to:

1. The numbers and diversity of contributing mine-related sources;
2. The approach and level of detail selected for assessment analysis;
3. The availability and format of existing mine-related source location and description data;
4. The characteristics and the distinguishing features of each mine-related source subcategory which is to be recognized and described;

5. The physical distribution of various mine-related sources within a given planning area, as well as the overall area size;
6. The availability of various means of data acquisition suited to local requirements for mine-related source location and description, and the practicability of various means of transforming and manipulating existing data; and
7. The availability and completeness of State regulatory records, Federal NPDES permit information, local county records, Federal lands mining data, and other mine-related source information within the planning jurisdiction.

The U.S. Bureau of Mines and Soil Conservation Service publish information gathered from State agencies and local groups on the number of inactive and abandoned underground mines and acreages of land disturbed by surface mining in each State, and the acreage of land utilized by the mining industry for extraction and waste disposal by mineral commodity and State.

Some of the various information sources which can be used for mine-related source location and description are:

1. Existing general and special purpose maps, including Economic Geology maps published by State Geological Surveys, U.S. Geological Survey maps, State and regional land use maps, and industrial mine-related operations maps;

2. Regulatory mineral extraction and mineral waste disposal permit system records, including Federal Land Management Agency, NPDES, State, and local sources;
3. Mine location data from public safety and occupational health and safety programs at the Federal and State levels;
4. County and local municipality information;
5. Previously conducted special purpose mining inventory studies;
6. Mineral activity directories and tabulations;
7. Aerial photography and other forms of remote sensor data from which mining information can be interpreted; and
8. Onsite ground observation and low altitude aerial reconaissance.

WQM agencies should be careful in their use of large volumes of variably formatted mining and minerals data for locating mine sources, as such approaches can become bogged down in time-consuming data manipulation operations. A fresh, new mine inventory effort, based upon a single uniform data source with just the detail of information required, may deliver better survey results.

Numerous surveys and studies have been conducted which show the types and numbers of potentially contributing mine-related pollution sources within various regions of the country. The following EPA publications contain numerous citations of such studies and surveys:

1. "Processes, Procedures and Methods to Control Pollution from Mining Activities," EPA-430/9-73-011.
2. "Criteria for Developing Pollution Abatement Programs for Inactive and Abandoned Mine Sites," EPA-440/9-75-008.
3. "Inactive and Abandoned Underground Mines," EPA-440/9-75-007.

4. "Methods for Identifying and Evaluating the Nature and Extent of Nonpoint Sources of Pollutants," EPA-430/9-73-014.
5. "Water Pollution Caused by Inactive Ore and Mineral Mines, A National Assessment," EPA-600/2-76-298.

A general overview of mine-related water pollution problems is presented in "Water Pollution From Mining Activities in the United States", which was published in June of 1970 by EPA's predecessor agency, the Federal Water Pollution Control Administration.

EPA has also published a series of studies dealing with definition of ground water pollution, including that caused by mine-related sources, within several major geographic regions of the United States. These are:

1. "Ground Water Contamination in the Northeast States," EPA-660/2-74-056.
2. "Ground Water Pollution in the South Central States," EPA-R2-73-268.
3. "Ground Water Pollution in Arizona, California, Nevada and Utah," EPA-16060ERU12/71.
4. "Ground Water Pollution Problems in the Northwestern United States," EPA-660/3-75-018.

Utilization of Remote Sensor Data

This country's largest aerial photographic and remote sensor data distribution center is the EROS Data Center operated by the U.S. Department of Interior, Geological Survey in Sioux Falls, South Dakota. Most of the aerial photography and imagery (including Skylab and LandSat data) acquired by the various Federal government agencies is catalogued or held by the EROS facility. The mailing addresses of several Federal agencies that maintain aerial photographic data storage, processing, and supply facilities are given below:

1. User Services
   EROS Data Center
   Sioux Falls, South Dakota 57198

2. Aerial Photography Field Office
   Agricultural Stabilization and Conservation Service
   U S. Department of Agriculture
   2222 West 2300 South
   P. O. Box 30010
   Salt Lake City, Utah 84125

3. Soil Conservation Service
   U. S. Department of Agriculture
   Room 5118 South Building
   Washington, D. C 20250

4. Forest Service
   U. S. Department of Agriculture
   Room 1201 S RPE
   P. O. Box 2417
   Washington, D. C. 20013

5. National Ocean Survey
   Room 526 - Building #1
   U. S. Department of Commerce
   6001 Executive Boulevard
   Rockville, Maryland 20852

Remote sensor data may be used to locate various mine-related sources (i. e., mineral extraction sites, mineral waste disposal areas, access and haul roads, etc.) at the level of interpretive detail consistent with the information requirements of the selected assessment analysis approach. The presence of mine-related sources may simply be recognized, or sources may be more carefully identified and delineated. Source area conditions may be described, and pollution hazards and impacts analyzed through associated field studies.

Manual remote sensor data interpretation techniques are likely to deliver the most practical results when pollution hazard analysis is to be performed concurrently with simple mine source identification.

Computer-assisted interpretive techniques may be useful for development of generalized land cover/land use information and for specific identification and general description of sources when mine targets are sufficiently large and contrast with their surroundings in the spectral region(s) represented. Pollution hazard analysis may be performed using automated techniques if the prequisite topographic, hydrologic, geologic and climatic data has been digitized, and a suitable interactive geocoded data manipulation system and multi-variate pollution hazard analysis model exists. Scale, vintage (year acquired) and format of aerial photography or imagery for mine source location must match with similar characteristics of other forms of data with which mine source information is to interact during assessment analysis. Other data forms may include underground mine location maps, topographic maps, geologic maps, surface water drainage maps, ground water hydrology maps, mine permit records, etc.

Remote sensing information is well suited to multiple category rural land use classification. This system estimates pollution load contributions by the number of acres within each land use class which contributes to pollution loads in each drainage segment. This method of analysis integrates the mine-related source assessment effort with construction, silviculture, agriculture, and other pollution source categories.

2.2.5 Interpretation of Existing Water Quality Data

Maximum use should be made of existing water quality data to describe the present extent and severity of mine-related water pollution. New data may be needed to correct serious limitations and deficiencies in existing data; but to the extent feasible, emphasis in new data acquisition should be placed on improved monitoring in support of ongoing regulatory and abatement programs, rather than on monitoring as a part of problem assessment studies.

Section 5.3.2 of the EPA publication "Methods for Identifying and Evaluating the Nature and Extent of Nonpoint Sources of Pollutants", discusses empirical aids for interpretation of routinely acquired data used to monitor water quality for mine-related pollution information. One of the principal drawbacks to using standard water quality data is the variability of the combinations of storm events and base flow conditions often represented in the pollutant concentration data. Frequent lack of matching flow information is yet another common limitation to existing data.

Use of existing water quality monitoring data to define the extent of mine-related pollution represents a stream-to-source approach. It can be used at the basin or sub-basin level in those instances involving conservative pollutants where background loads can be accurately estimated and where sufficient in-stream water quality data are available. Pollutant load estimates are prepared using this stream-to-source approach based upon the difference between total loads (observed) and background loads (estimated). This approach can be used when the actual numbers and locations of mine sources have not been identified, or when too few mine sources exist to permit use of loading functions.

Existing ground water quality data and information on surface water/ground water relationships should be used to provide an initial grasp of mine-related ground water pollution impacts. The quantity and the accuracy of existing data dealing with ground water may frequently be less than that available for surface water because ground water data are more difficult to obtain and to interpret. Useful information about ground water quality monitoring and mine-related impacts is included in these recent EPA publications: "Rationale and Methodology for Monitoring Ground Water Polluted by Mining Activities," EPA-680/4-84-003, July 1974; and "Monitoring Ground Water Quality: Monitoring Methodology," EPA-600/4-76-026, June 1976.

2.2.6 Assessment of Existing Source Impacts

Assessment of mine-related source impacts must be accomplished using both biological and chemical information. Even when gathering of new aquatic biological information is not a part of the assessment effort, the effects of various pollutant concentrations on aquatic life must be known or estimated to define impacts on the water quality goal ("water quality that provides for the protection and propagation of fish, shellfish, and wildlife . . ." etc.).

Alternative Approaches

The best method for I and A of existing mine-related water pollution contributions will depend upon the extent, diversity, and distribution of mine-related sources. The methodology used for I and A will also be influenced by the present availability of mine-related pollution data and by the presence of especially hazardous or toxic contributions from particular mine source subcategories.

Identification and assessment may be accomplished either by:

1. Description of the relative hazards and impacts on beneficial water uses (largely in other than quantitative terms) created by various mine-related pollution sources; or by
2. Quantitative description of pollutant loadings, transport, resultant concentrations and impacts through use of loading models, transport models, water quality impact models, and beneficial use impact estimation methods.

Quantitative description of impacts assumes that quantitative information is essential to WQM program requirements, that adequate data can be obtained, and that models and analytical procedures have been identified which will yield reliable results under the conditions prevailing within a given planning jurisdiction.

A. Quantitative Impact Description

Existing mine-related pollutant loads and load impacts may be determined either by quantitative description or by description of relative pollutant hazards and effects on beneficial uses. This section discusses the quantitative approach.

EPA's "Areawide Assessment Procedures Manual," EPA-600/0-76-014, describes the currently available alternatives for pollutant load modeling. These include empirical methods, deterministic methods, stochastic methods, and simulation methods. Empirical methods, such as the Universal Soil Loss Equation, the Modified Musgrave Equation, and various loading functions represent the most easily applied methods. However, application of any of the empirical methods requires local calibration and testing or verification. Quantitative assessment is also not complete until the loading model outputs have been input to suitable pollutant transport and water quality impact models. Instream water quality impact models must include procedures to accept loadings data from loadings and transport models, and must deal with instream water pollutant reactions, transformations, and interactions.

Most quantitative loadings estimation and water quality impact modeling procedures deal with broadly generalized instream concentrations in large watersheds rather than with specific temporally varying near-site effects upon receiving water quality and aquatic life. Only the most extensive and the most pervasive forms of mine-related pollution usually eminating from hundreds or even from thousands of individual contributing sources can be identified and assessed using very generalized methods. A current or abandoned mine-related source or source subcategory which may be contributing only a minute proportion of the total load within a given major watershed, may, at the same time, be responsible for devastating impacts on aquatic life within a few small stream tributaries or short drainage segments located within that watershed.

Estimation of mine-related sediment loads may be attempted using the Universal Soil Loss Equation (USLE). Sediment loads may be estimated to a limited extent for individual mine-related sources and storm events, but procedures are best developed for estimating annual average values from large numbers of sources in aggregrate. Both general average and specific source estimates of sediment loadings from mine-related sources can be unreliable, in part because of uncertainty in the sediment delivery ratio. The Universal Soil Loss Equation (USLE), developed primarily for application to croplands east of the Rockies, may be applied to mine-related sources only when coefficients have been empirically derived to reflect local source conditions.

Some of the specific sub-tasks for which quantitative mine-related pollutant load information may be used as a part of an assessment effort include:

1. Description of existing receiving water quality conditions with consideration of pollutant inputs from all point and nonpoint source categories;
2. Description of point and nonpoint mine-related source impacts on receiving water quality at both high and low flow design states;
3. Comparison of mine-related pollutant impacts with other category pollutant impacts; and

4. Comparison of the impacts of various mine-related source subcategories with one another.

The present state-of-the-art may not permit reliable results to be obtained from the input of quantitative mine-related pollutant loadings data into mass balance water quality impact models. Stream segment models, estuary models, impoundment models, and stormwater analysis models have very limited or no capability to deal with nonsteady state, variable flow, variable pollutant input conditions characteristic of intermittant point sources, and runoff-related nonpoint sources. Nonpoint sources are particularly variable, and methods of quantitatively estimating loadings of sediment, acid, heavy metals, and other pollutants are crude at best.

Modeling is recommended only within carefully chosen watersheds where available mine-related pollution load input data and analytical procedures are judged adequate to yield realistic results.

Even though mine-related source modeling presently offers only limited opportunity for application, the predictive power of models for describing in-stream conditions under critical flow stages makes them a very useful WQM tool. Efforts to develop adequate models for future use should be encouraged.

Modeling offers many advantages for predicting the results of different abatement or control strategies, or for identifying conditions which might produce violations of water quality goals. Efforts to develop reliable models to support the continuing WQM process deserve support, even though modeling often may not be used in the initial WQM program work. Estimates of impacts from abandoned sources are better suited to the modeling approach than are estimates of current source impacts. Active strip mine pollutant loads and haul road loads contributed during active operations are examples of particularly dynamic sources which can change rapidly. Abandoned mine sources are good examples of sources whose contributions may decay slowly over a period of many years and may be more easily modeled.

At least three general options can readily be identified for estimating pollutant loadings during existing source identification and assessment. These include the loading function approach, the representive sampling approach and the site specific analysis approach.

1. Loading Function Approach - The loading function approach is most appropriate when numerous and extensive mine-related sources exist within a very small number of subcategories (low source diversity). This approach normally is applied at the basin or major sub-basin watershed level. The number of contributing sources in each mine-related subcategory must be estimated. Loading functions represent a source-to-stream approach which is applicable only where sufficient prior research and water pollution data for the same or similar watershed areas are available.

Use of generalized loading functions for estimating mine-related pollution contributions is explained in the EPA publication, "Loading Functions for Assessment of Water Pollution from Nonpoint Sources," EPA-600/2-76-151, May 1976. Loading functions for estimation of sediment, acid mine drainage, heavy metals and radioactivity from mine-related sources are presented and discussed.

Generalized estimates of surface and underground coal mine pollution loads were developed and presented in EPA's "National Assessment of Water Pollution from Nonpoint Sources," October 1975. This study contains estimates of the numbers of surface and deep active and abandoned coal mines by major and minor basins across the United States. It also includes numerical estimates of sediment loadings in tons per day and acid mine drainage loadings in pounds $CaCO_3$ equivalent per day.

2. Representative Sampling Approach - The representative sampling approach will be found to apply more often than any other general method. This approach represents a "middle ground" between loading functions and site specific analysis. It applies where there are not enough mine-related sources in any one subcategory to permit realistic use of loading functions, but where sources are still too numerous to permit site specific analyses.

The representative sampling approach requires subcategorization of existing mine-related sources to reflect similarities in pollutants and pollution delivery potential. A very limited number of sample sites are selected from the mine source population within each subcategory or from the population of stream segments or watersheds influenced by contributions from each subcategory. Chemical and/or aquatic biological information may be acquired at each representative sampling site. Most specific mine sources are individually located, but the number of sources in particularly difficult to locate subcategories (i.e., abandoned deep mine discharges, etc.) may be estimated from existing data or limited sampling.

Where representative watersheds impacted by mine-related contributions are selected for sampling, samples should be taken proportional to the hydrograph flow pattern to provide an estimate of peak pollutant concentrations and total loadings for each pollutant.

Water quality data which has been selectively acquired from specific mine-related sources or watersheds to be representative of pollutant loads contributed by other similar sources or of watersheds impacted by other similar source assemblages may be used to estimate contributions from unmeasured sources or impacts on unmeasured watersheds. Relative pollutant delivery or impact potential, within different subcategories can be comparatively ranked. Estimates of mine-related source loads and impacts can be compared with the estimated pollutant contributions and impacts from sources within other categories (agriculture, etc.) Once loads from various mine-related source subcategories have been estimated, limited storm event discharge and runoff sampling can be used to validate estimated loads and relative magnitudes of pollutant contributions.

3. Site Specific Analysis Approach - Site specific analysis may be used as the principal method for existing source identification and assessment in those cases where relatively few sources are present within a very limited number of source subcategories (low source diversity). This method may be especially appropriate for assessing the impacts of particularly hazardous or toxic pollutants. Normally site specific analysis involves chemical water quality monitoring for loading and transport model calibration and verification, aquatic biological data collection, and loadings, transport, and in-stream pollutant load impact modeling. Water quality monitoring involving large numbers of individual sources should normally be avoided. Monitoring efforts of this kind are more likely to be appropriate as a part of advanced implementation efforts (such as in watershed engineering feasibility studies conducted under abandoned mine pollution abatement programs) than as a part of the initial WQM program effort.

Under circumstances involving large numbers of abandoned mine sources, monitoring normally should be directed toward description of a relatively small number of the most severe contributing sources.

B. Relative Water Quality and Beneficial Use Impact Description

This approach to assessment involves comparing the impact potential of various mine-related source contributions with one another, and with the impacts of contributions from sources in other categories.

Relative pollution hazard description is based on an understanding of the interrelationships among mine-related pollution sources, pollutant delivery mechanisms, and receiving water and aquatic life characteristics.

Biological information is required to determine mine-related pollutant impacts on beneficial water uses. Limited quantitative water quality data (chemical) can be used in conjunction with biological observations to support judgements of the degree of impact pollutants from various mine source subcategories have on aquatic life. Biological information frequently may be more useful for defining pollution problems than chemical water quality data; this is so because biological data relates directly to beneficial use impact, while water quality data, once gathered, must still be further analyzed and interpreted for its beneficial use implications.

Aquatic community diversity indexes have been used to advantage to measure impacts of mine-related pollutants on aquatic life. More exhaustive and sophisticated bioassay work such as the study of pollutant accumulations in plant cells and animal tissues probably should not be undertaken by WQM agencies except where more general information has identified specific problems requiring in-depth examination and where the results may have some bearing on revision of Water Quality Standards and/or on the choice of appropriate preventative and control practices. Aquatic life forms most often sampled in past studies have included insects, fish, crustaceans, diatoms, algae, and bacteria. The health and survival of many non-aquatic life forms, such as beaver, waterfowl, etc., are also closely linked to water and water quality as habitat requirements, but examinations of mine-related water quality and hydrologic impacts on habitats of these animals have rarely been attempted.

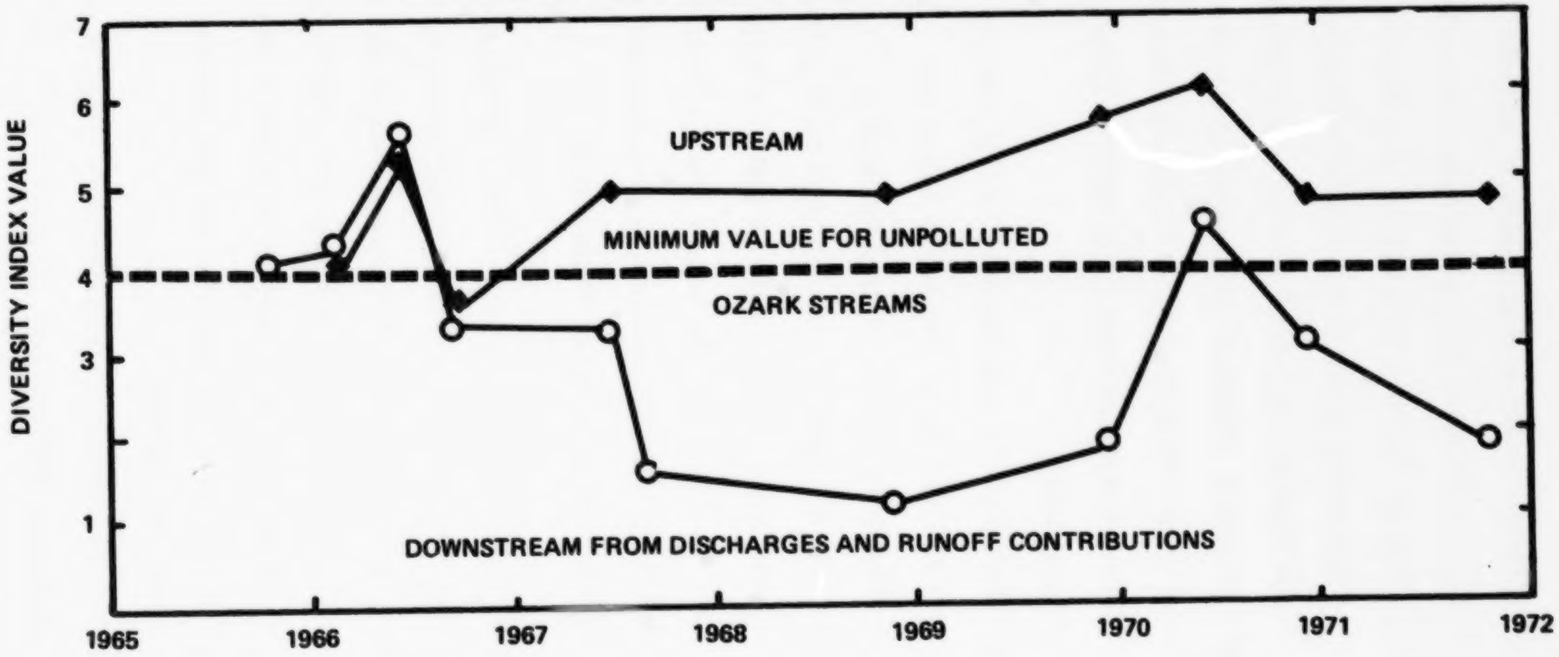
Figure 2.2 illustrates the results which were obtained by Ryck (1973)[1/] using Wilhm's benthic community diversity index to guage the impact on aquatic life of pollutant contributions from lead mine-mill complexes in the streams of southeastern Missouri. All streams receiving pollutant contributions from lead mine-mill complexes showed lower diversity index values (below 4) after mining was started, while all control receiving streams were found to have higher indexes (greater than 4) prior to the initiation of mining operations. In this example, both the total number and the types of benthic organisms in receiving streams declined once mining began.

Once the type and relative magnitude of the pollution problem is understood, mine-related source identification information provides a sound grasp of how widespread or pervasive the problem may be in relation to other point and nonpoint source problems.

An analysis of relative hazards presented by pollutant contributions from various mine-related sources should be adequate to:

[1/] Ryck, F J. Jr. "Water Quality Survey of the Southeast Ozark Mining Area, 1965-71." Interim Report, State of Missouri. Project Study W-2 No. 1. 1973.

FIGURE 2.2 — DIVERSITY INDEX VALUES UPSTREAM AND DOWNSTREAM FROM A TYPICAL ZINC MINE—MILL COMPLEX [AFTER RYCK (1973)].



1. Separate relative magnitudes of pollutant contributions from abandoned versus current mine-related sources;
2. Separate relative magnitudes of pollutant contributions from easily controlled sources versus very difficult and expensively controlled or abated sources;
3. Provide a realistic comparison of the adverse impacts of mine-related pollutant contributions with the effects of contributions from other water pollution source categories;
4. Contribute to identification of the specific receiving waters segments, recharge zones, etc., most severely impacted by mine-related pollutants;
5. Provide a basis for sound judgement of the relative importance of mine-related pollutant impacts within the framework of the larger WQM effort; and
6. Identify the most productive direction and focus for further mine-related WQM effort.

Mine-related source characteristics within each subcategory should be described in relation to their exemplification of relative pollution hazards. Quantitative load estimation procedures such as the empirical Universal Soil Loss Equation (USLE), which may not yield very accurate absolute pollution load estimates, may nevertheless aid in understanding how pollution potential may vary with specific changes in mine-related sources and local climatic conditions.

Mine-related source characteristics which may be important for definition of relative pollution potential include:

1. Type of mineral commodity involved;
2. Type of mineral industrial operation, and method of operation used;
3. Age and activity status of the mine-related operation;
4. Preventive water pollution control measures previously applied or presently being applied during the operation;
5. Topographic situation of the mine-related source;
6. Internal relief and hydrologic interaction of mine sources with surrounding surface drainage and ground water;
7. Mine source surface runoff and water infiltration properties;
8. Affected area surface cover characteristics, especially vegetation;
9. Physical interactions of deep mine workings with any existing oil, gas, or water wells, and with the surrounding ground water;
10. Opportunities for chemical weathering of minerals exposed in underground workings and for transport of soluble products;
11. Geochemical composition and physical properties of the associated geologic and soils materials;
12. Geologic structure, faults, joints, etc., and arrangement of mineral strata in relation to site hydrology; and
13. Drainage density and proximity of mine-related sources to receiving waters.

Climatic and hydrologic parameters closely associated with pollutant delivery mechanisms to receiving waters include:

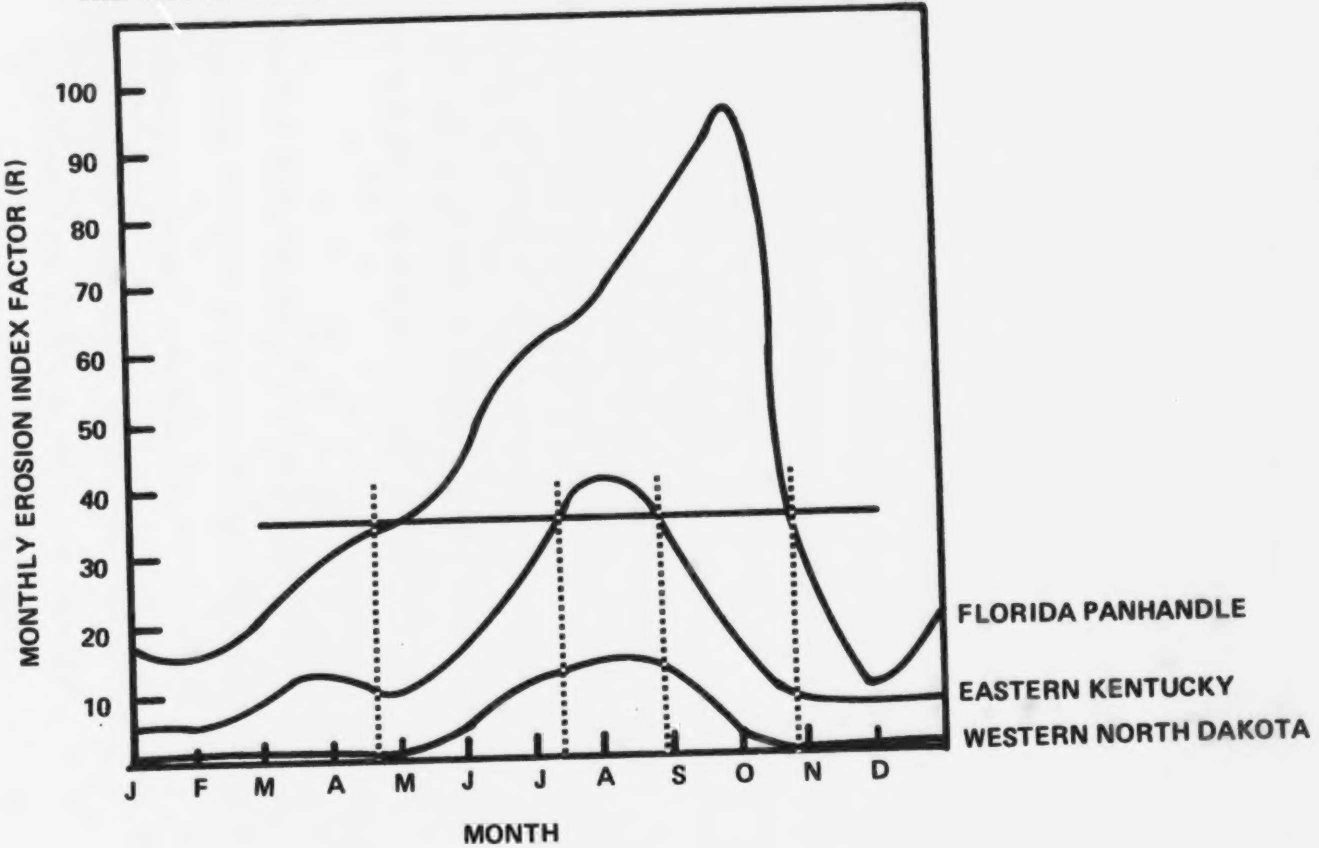
1. Amount and timing of rainfall and snowfall;

2. Time variation of temperature;
3. Time variation of rainfall energy/intensity and the erosion index;
4. Growing season duration and timing of associated phenological plant responses;
5. Time variation of wind speed and direction;
6. Location and characteristics of ground water aquifer recharge zones;
7. Ground water depth, strata permeability, and hydrologic flow characteristics; and
8. Time variation and quantities of runoff in the vicinity of the mine source.

Climate, and especially rainfall, is often the single most important driving force in producing nonpoint source pollution. One of the most important characteristics in determining rainfall's potential as an erosion and sediment transport mechanism is the energy-intensity (EI) of any given storm or the rainfall-erosivity index (R) which represents the annual sum of all individual storm EI values at a given location.

Figure 2.3 compares the monthly rainfall erosion index occuring during the average year at three locations in the United States. The three areas are the Florida panhandle, eastern Kentucky, and western North Dakota. The mean annual precipitation in the Florida area is 55 inches to 60 inches per year; in the Kentucky area, 45 inches to 48 inches per year; and in the North Dakota area, 12 inches to 16 inches per year.

FIGURE 2.3 — COMPARISON OF MONTHLY EROSION INDEX OR ENERGY—INTENSITY OF RAINFALL DURING THE AVERAGE YEAR IN EASTERN KENTUCKY, THE WESTERN FLORIDA PANHANDLE AND WESTERN NORTH DAKOTA[1]



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[1] AFTER "PREDICTING RAINFALL-EROSION LOSSES FROM CROPLAND EAST OF THE ROCKY MOUNTAINS", AGRICULTURE HANDBOOK NO. 282, ARS-USDA. MAY 1965.

In eastern Kentucky, the highest monthly erosion index of rainfall occurs during a six week period in July and August. This same erosion index level is reached or exceeded in the western Florida panhandle in the six months between May and October. The highest monthly erosion index value which occurs in August in North Dakota is reached or exceeded all year long in the Florida area, except during a one month period in November/December. The highest monthly erosion index value in the Florida panhandle is six times larger than the highest value reached during the year in North Dakota, and more than twice the highest monthly value reached in eastern Kentucky. Snowmelt runoff may present a substantial potential for causing erosion especially in some of the semi-arid regions of the country. The effects of snow melt runoff may partially offset the effects of lower rainfall-induced erosion in some areas.

Rainfall information is available from the U. S. Department of Commerce National Weather Service (formerly the U.S. Weather Bureau), both in the form of raw precipitation data and in the form of analytical data about storm frequencies and durations at weather stations across the country.

Important descriptive characteristics of receiving surface waters and ground water include:

1. Diversity and composition of aquatic plant and animal life, and susceptibility to being impacted adversely by mine-related pollutants and hydrologic modifications;
2. Premining surface water and ground water quality and uses;
3. Recreational water use demands and their timing;
4. Time variability of water flow volume;
5. In-stream water quality;

6. Background water quality characteristics;
7. Bedload, benthic deposit; and bank characteristics;
8. Point source loads and flows;
9. General variation of water regimen with timing of individual storm events;
10. Water pollutant load contributions from other source categories (construction, agriculture, etc.);
11. Chemical composition of precipitation; and
12. Interrelationships among runoff, infiltration, ground water levels, flow, recharge and discharge and surface water flow (hydrologic balance).

Other aids to an analysis of the interrelationships among water pollutant contributions and their impacts (sources, transfer mechanisms, receiving waters) can be found in reservoir and catch basin sediment studies, new or previously documented biological impact and aquatic surveys, and recorded citizen complaints concerning adverse mine-related water quality impacts on recreation, aquatic life and other beneficial uses.

CHAPTER 3.0

CURRENT SOURCE CONTROL

3.1 Introduction

Current mine-related sources of surface water and ground water pollution include all point and nonpoint sources associated with all active mineral industrial operations and with all inactive operations controlled by Federal, State, or local regulations.

State WQM agencies (in some cases, areawide agencies) are responsible for seeing to it that control systems for current mine-related sources are developed and implemented which are sufficiently effective on-the-ground to achieve water quality goals and to protect designated beneficial water uses.

WQM agencies can work toward improved control of current sources by initially working together with existing mine-related regulatory authorities and with representatives of the mine-related industries. Point source water pollution control authorities (Federal or State) exist in every State; these authorities principally regulate under NPDES mine dewatering and process waste water discharges from mineral extraction and mineral processing and milling operations. Control of mine-related nonpoint sources in any phase of mineral industrial operations must be accomplished through use of Best Management Practices (BMP's). A regulatory process must be established within the framework of each mine-related control system which either specifies, or is effective in identifying BMP's appropriate to each mine-related nonpoint pollution source. The control system process must also assure that those preventive measures and control practices which are identified are, in fact, utilized and that water quality goals are achieved and beneficial uses protected. Translating general control principles into specific practices within a regulatory control system framework is discussed further in Chapter 4.0.

WQM agencies should carefully examine existing control systems in an attempt to answer the following basic questions:

1. Are all sources controlled?

   Are all contributing mine-related sources of surface water and ground water pollution which are understood to threaten achievement of water quality goals subject to control under any existing system(s)?

2. Are controls effective?

   How effective in controlling and preventing water pollution from mine-related sources is any existing control system(s)?

3. Are BMP's specified or identified?

   Are "Best Management Practices" appropriately specified or identified for preventing and controlling pollution from mine-related nonpoint sources?

4. Is legal authority adequate?

   Does adequate legal authority exist to assure proper identification and to require use of appropriate BMP's?

5. Are controls technically adequate?

   Has that legal authority been translated into a technically adequate regulatory process and/or into specific regulations which can achieve effective control? (Effective control implies control sufficient to achieve water quality goals and protect beneficial water uses).

6. Are organization, support and enforcement adequate?

   Does the control system provide adequate budgetary support, administrative support, institutional arrangements, management, coordination and enforcement to achieve effective control?

3.2. Overview of Mine-related Control Systems

Existing mine-related control systems which have been established by Federal, State and local units of government often were designed to serve objectives other than or in addition to water pollution control. Some of these other objectives are aesthetics, rights of adjacent and affected land owners, maintenance of land productivity, protection of terrestrial ecological values, prevention of subsidence, public and occupational safety and health, collection of severance taxes, proper recording and transfer of mineral rights and payment of royalties, and reclamation, and postmining land use. Reclamation is consistent, but not synonomous, with water pollution control. Reclamation more directly serves the goal of returning previously mined lands to productive use, that it does the objective of preventing and controlling surface and ground water pollution during and following mining.

Existing mine-related laws and regulations may apply separately to each phase and to each aspect of mineral industrial activity or they may apply to all or to varied groupings of such activities. Mine-related operations are also sometimes regulated under broad control systems which encompass sources in several categories. For example, an erosion and sediment control law may be applicable to agricultural, silvicultural, and construction sources as well as to mine-related sources. Some of the mineral industrial subcategories which may be regulated under existing control authorities include surface mining, open pit mining, deep mining, oil and gas production, coal mining, metallics mining, nonmetallics mining, mineral waste disposal, mineral storage operations, mineral transport operations, mineral milling and processing operations, etc.

Each mine-related control system (or BMP identification and use enforcement process) which serves nonpoint source water pollution control objectives achieves its own peculiar balance between mine-related law, regulations, field practice guidelines, specific permit stipulations, and requirements identified through field inspections. While legislative bodies may enact generalized laws for preventing and controlling water pollution, they usually authorize a management agency to establish more detailed rules and control regulations. When developing rules and regulations, designated management agencies may still not define the small details of mine-related practices and require their use across-the-board. More often these agencies rely upon a pre-operations planning and regulatory permit process to identify specific preventive measures and control practices or BMP's to be applied to each mineral industrial operation. This approach is likely to be effective however, only where sufficient numbers of well-qualified technical personnel are employed in the regulatory permitting program to thoroughly review each permit application to identify appropriate and effective preventive measures and control practices for each site, and/or to check the appropriateness and effectiveness of those proposed by the operator. Adequate site specific physical and biological data must also either be supplied by the operator with each permit application or be collected by the regulatory agency to support a meaningful site specific control needs and BMP identification process. Use of these specific BMP controls can then be required by making conformance to the details of the approved mine-related operations plan (reclamation plan, drainage control plan, etc.) a mandatory part of permit compliance. Authority should also allow the regulatory authority to identify and require compliance with additional or modified preventive measures and control practices arising from on-site inspections and evaluations conducted during the course of the operation. Management agencies frequently provide mine operators and mine inspectors with field guidance manuals that contain detailed descriptions and specifications for desirable mining practices and control techniques and methods. While information in field manuals may not be mandatory, it is intended primarily to aid the industry and mine inspectors in designing and judging the adequacy of controls installed at each operation.

Some specific details of mine-related field practice which are generally applicable and important for control at all sites may be included directly in control law or be specifically required in rules and regulations. For example, gradient limitations for steep slope surface mining and for mine haul roads in mountainous terrain are common examples of specifically regulated details of field practice.

Mine-related water quality control programs originally conceived for control and prevention of some form of chemical pollution or toxic contamination (such as surface discharges of acid mine drainage), may require revision and expansion to properly address all aspects of affected area erosion and sediment control, ground water contamination, and hydrologic balance disruption.

No mine-related regulatory control program will be 100 percent effective in preventing and controlling all adverse water quality and hydrologic impacts. The effectiveness of control systems will vary with the specific makeup of the mineral industry; the field conditions at mine-related operations sites; the adequacy of laws, rules, and regulations; the state of control technology; and the institutional, administrative, financial, and management aspects of the control system.

The concept of "risk" may provide a useful perspective for designing regulatory control systems. Even when the control system is oriented toward accomplishment of pollution control objectives, specific techniques and measures applied by the industry, and/or the whole control system, may fail to achieve intended objectives. Before changing an existing control system or implementing a new system, WQM agencies should attempt to judge the percentage of full effectivenesss achieved by the existing system or likely to be achieved by the new system.

The WQM agency should estimate the failure rate that may be expected from steep fill slopes on mine haul roads, from dike walls surrounding mine waste disposal areas, or other mine-related features, if they are designed and built under current industrial practice.

When a government agency permits mine-related operations with controls that fail to achieve stated objectives for prevention and control of adverse water quality impacts, these operations may generate unplanned and unacceptably high levels of pollution.

An effective and adequate mine-related regulatory control system is one which:

1. Includes a regulatory process designed to identify or specify and require use of BMP's to prevent and control water pollution from all contributing mine-related nonpoint sources;
2. Specifically assigns control responsibility for postmining pollution and the terms of release from that responsibility in such a way as to preclude any further growth in water pollution loadings and adverse beneficial use impacts from abandoned mine-related sources;
3. Regulates all contributing mine-related point sources, and all those nonpoint pollution sources which cause adverse water quality and beneficial water use impacts. These may include contributing sources associated with all areas affected by mineral exploration, mine development, mineral extraction, including surface effects of deep mining, mineral transport, mineral processing, mineral storage, and mineral waste disposal;
4. Prevents and controls both surface water and ground water pollution, chemical pollution (mine drainage), sedimentation, thermal pollution,

fugitive dust sources linked to water pollution and mine-related hydrologic disturbances which result in chemical pollution, sedimentation or damage to aquatic habitat;

5. Incorporates an ongoing procedure for evaluation through chemical and biological monitoring of the effectiveness of the control system in achieving its stated control objectives related to water quality, water quality goals and beneficial water uses;
6. Includes a process for ongoing examination of new mine-related practices and control techniques and a requirement for prompt adoption of improved practices when they become sufficiently well developed for widespread application;
7 Separates the mineral industrial promotion functions of government from the regulatory responsibilities of the management agency to avoid conflicts of interest;
8 Develops feedback mechanisms to continually redirect and focus mine-related pollution control research efforts on the most significant control problems;
9. Does not preclude local zoning action following State or other governmental mine-related permit approval;
10. Provides penalties sufficient to discourage intentional violations and makes mine operators responsible for correcting adverse hydrologic impacts, whether caused by willful violation or unforseen problems;
11. Includes provision for designating areas unsuitable for mine-related operations or for denying individual permits if the uncontrollable or inadequately controllable water quality and hydrologic impacts outweigh mineral industrial, and other economic or social gains;
12. Incorporates a WQM process to examine the effects of each mine-related operation in relation to existing sources, to future operations, and to

other activities and contributions from all other source categories impacting water quality. This process operates as a part of the permit approval procedure for mine-related operations;

13. Assures regulatory agency control of mining methods insofar as those methods affect prevention and control of surface and ground water pollution and adverse hydrologic impacts.
14. Specifically assigns pollution control responsibility throughout any and all periods of inactivity; and
15. Specifically addresses final disposition and continuing maintenance of all roads, sediment basins, and other structures remaining after mine-related operations are completed.

3.3 Current Source WQM Tasks

The essence of WQM program work involves an objective evaluation of on-the-ground effectiveness of existing control systems, identification of specific deficiencies and limitations in those systems, and setting forth definite plans and schedules for improvements and implementation of more effective controls. Following is a brief description of the major tasks involved in carrying out a current source WQM work program:

WQM Task - Perform a preliminary examination of existing laws, regulations, and institutions applying to prevention and control of surface water and ground water pollution from current mine-related sources.

Examination of mine-related pollution control laws and institutions across physiographic provinces or multi-state mining districts can help WQM agencies to compare regulatory controls in their individual States and jurisdictions with those in other areas. Examination of pollution controls and approaches being applied by other States with similar mineral industrial operations can point useful directions for control system improvement.

WQM Task - Select one or more of the institutions which are active in control programs to participate with the WQM agency in setting up and carrying out a current source WQM work program.

WQM Task - Solicit involvement from State and Federal wildlife management organizations to insure that mine-related WQM efforts are defined consistent with and supportive of wildlife management objectives, plans and programs.

WQM Task - Evaluate the effectiveness of the existing mine-related regulatory control system(s) in prevention and control of water pollution. Control system components include existing laws, rules and regulations, institutional arrangements, and administrative and management functions.

WQM Task - Analyze surface water and ground water hydrology of representative mine-related sources which correspond to previously identified pollution source subcategories. (An example mine site hydrologic examination containing point and nonpoint source descriptions is given in Appendix A)

WQM Task - Identify preventive measures and control practices for prevention and control of identified surface water and ground water pollution sources. (Examination of mine-related industry actions with a view toward recognizing, preventing and controlling adverse impacts is discussed in Appendix B.)

WQM Task - Solicit involvement from the minerals industry in proposal of preventive measures and control practices and in estimation of costs and readiness for practical application.

WQM Task - Classify proposed preventive measures and control practices on the basis of their readiness and suitability for practical application in the field.

WQM Task - Perform selective monitoring of current mine-related operations to support judgments of the need for and effectiveness of specific measures and practices.

WQM Task - Develop pollution control strategies for application to each identified current mine-related source subcategory.

WQM Task - Estimate the effectiveness of the various control methods, measures, practices and strategies for prevention and control of current mine-related pollution contributions.

WQM Task - Identify regulatory control system deficiencies and technical control limitations.

Deficiencies in the regulatory control system include all contributing pollution sources that are presently unregulated or inadequately regulated and which interfere with achievement of water quality goals and protection of beneficial uses. Deficiencies also include those areas where existing authority is not sufficient to permit application of proposed control strategies. Technical control of contributing pollution sources may be a limiting factor where control techniques do not exist, where they are not ready for practical application or where they are not sufficiently effective to achieve adequate control. Emphasis in research to control mine-related pollution should be focussed on these technical control limitations.

WQM Task - Formulate alternative subplans for control of current mine-related pollution sources in each recognized source subcategory.

Discussion of Alternative Control Subplans

Several control subplan alternatives can be described and used as points of reference in the process of subplan selection.

Three control system variations that may serve as comparative references include: (1) the existing regulatory control system; (2) a technology performance limited system incorporating the best preventive measures and control practices currently available; and (3) a fully effective control system which introduces land use controls as a means to prevent pollution from inadequately controllable and presently uncontrollable current mine-related pollution sources. Land use requirements represent a control alternative which is applicable to new operations and future expansion of current operations.

Description of the existing system should focus on uncontrolled and inadequately controlled surface water and ground water pollution which is characteristic of operation of the present system.

Description of a system which is limited only by present field technology should focus on describing the improved control over pollution sources possible through application of the best currently available preventive measures and control practices, or BMP's. As a part of this system description, current pollution sources should be evaluated to determine which are technically controllable, and which are inadequately controllable through application of BMP's. Any analysis of the economic consequences to the mining industry of applying BMP's and complying with control system provisions should be responsive to the specific concerns of those State and local institutions, mine-related industries, and interest groups who will be affected most directly by BMP application. In the past, legislative bodies engaged in drafting mine-related control laws have sometimes specifically identified requirements, and in other cases have waived any requirement, for demonstration of economic feasibility of compliance with regulatory provisions, control practices and preventive measures (BMP's) which would be required under the proposed control system.

Description of a fully effective control system should focus on identification of land use requirements deemed necessary to prevent mine-related pollution when point source controls and the best available measures and practices will not be adequate to assure achievement of water quality goals and protection of beneficial water uses. Achievement of adequate control may prove to be unattainable not only because of the technical limitations of treatment and BMP application, but also because of the performance limitations of regulatory control systems.

The environmental assessments of alternative control subplans should focus on those few areas which are likely to exert the greatest influence on subplan selection. In most instances, the water quality and beneficial use protection implications, and the economic consequences of subplan implementation, will be the key impact factors.

Land use requirements may relate to:

1. Prohibition of specific mine-related industrial operations in critical or sensitive areas, often with periodic review requirements;
2. Designation of areas as fully, partially, or conditionally unsuitable for specific mine-related industrial operations, often with periodic review requirements;

3. Individual mine-related operations permit denial procedures;
4. Local zoning requirements restricting mine-related land uses; and
5. Denial of mine-related point source discharge permits.

Point source permit denial procedures may emerge from WQM agency compliance with Section 208(b)(2)(C)(ii) of P. L. 92-500, which requires that "Any [WQM] plan prepared under [a continuing water quality management planning] process shall include the establishment of a regulatory program to regulate the location, modification and construction of any facilities within . . . [the State or areawide planning jurisdiction] which may result in any discharge in such area."

Section 302(a) further states that "Whenever, in the judgement of the [U. S. EPA] Administrator [or of a State NPDES permitting authority], discharges of pollutants from a point source or group of point sources, with the application of effluent limitations required under Section 301(b)(2). . . , would interfere with the attainment and maintenance of that water quality in a specific portion of the navigable waters which shall assure protection of public water supplies, agricultural and industrial uses, and the protection and propagation of a balanced population of shellfish, fish and wildlife, and allow recreational activities in and on the water, effluent limitations (including alternative effluent control strategies) for such point source or sources shall be established which can reasonably be expected to contribute to the attainment and maintenance of such water quality."

Denial of permits for mine-related point source discharges or establishment of effluent discharge limitations more stringent than those required under Section 301(b)(2) may be necessary when such discharges and associated nonpoint source contributions are located on water quality limited segments, on existing high quality water segments or especially on high quality waters which constitute "an outstanding National resource, such as waters of National and State parks and wildlife refuges and waters of exceptional recreational or ecological significance" where according to Subpart 130.17(e)(2) of U.S. EPA Rules and Regulations "no degradation shall be allowed". WQM agencies should look especially to State and Federal wildlife management organizations for assistance in identifying National resource waters, in determining the sensitivity of idigenous fauna to various forms of water quality degradation and in recognizing potential impacts on rare and endangered species.

Where control systems involving application of point source effluent limitations more stringent than those required under Section 301(b)(2) of P.L. 92-500, use of the best available preventive measures and control practices or application of such measures and practices together with supplementary land use requirements are determined not to be practicable (i.e., following any of these alternatives would result in substantial and widespread adverse social and economic impact), at least one or more compromise control subplan alternatives will have to be prepared. Any such compromise subplan must be judged sufficiently workable for the responsible WQM agency to be confident of its implementation at the State or local level. The subplan description should identify the specific mine-related sources which may be inadequately controllable or uncontrollable; it should describe possible violations of water quality standards and goals, and resultant interference with protection of beneficial water uses. Established procedures must be followed to seek exception to designation of national goal water uses and standards in any water quality limited segment because of pollution contributions from existing mine-related sources.

No formal mechanism exists for downgrading water uses and water quality standards which are presently being achieved to permit new mine-related operations to take place which would result in uncontrollable, or in inadequately controllable water pollution leading to violations of water quality standards, or to failure to achieve water quality goals or to protect designated beneficial water uses.

WQM Task - Compare pollution loads anticipated from alternative control subplans with other nonpoint source pollutant load contributions, and with gross allotments for nonpoint source pollutants on water quality limited segments.

Earlier in the WQM process, gross allotments for each nonpoint pollutant are to have been established for nonpoint sources on water quality limited segments. The gross allotment is the maximum nonpoint pollutant load permissible under design flow conditions consistent with meeting revised Water Quality Standards. No widely accepted analytical process exists for allocation of pollutant loads along each water quality limited segment among point and nonpoint sources, and among different nonpoint source categories. Decisions related to nonpoint waste load allocation at this time are likely to be based upon social and economic considerations rather than upon the results of rigorous multiple category tradeoff analysis.

WQM Task - Select a current mine-related water pollution control subplan. The selected control subplan should represent the most effective implementable regulatory control system for preventing and controlling all forms of mine-related water pollution. The chosen system will reflect the best preventive measures and control practices currently available, supported by land use requirements as needed, and tempered by State and/or local social and economic constraints.

WQM Task - Prepare an environmental assessment for the selected current mine-related control system(s) included in the selected subplan. Environmental assessment is discussed in EPA's publication entitled "Environmental Assessment of Water Quality Management Plans" (October 1976).

The water quality and the economic implications (especially the costs of regulatory program management and administration) of the selected control subplan will have been described earlier in the subplan preparation process. A broader environmental assessment should be prepared for the finally selected subplan. This effort may involve some expansion of water quality and economic aspects as well as assessment of broader environmental (aesthetic, air, noise, terrestrial ecology, etc.) and social (development, economics, energy, etc.) impacts.

The subplan that is selected becomes an integral part of the overall WQM plan for the State or the areawide jurisdiction.

3.4 Control System Implementation and Continuing Water Quality Management

Control implementation for current operations is likely to be phased to avoid significant disruption to mineral production or to prevent other economic or technical problems. Mineral industry operations with a short term production life may be treated differently from those operations expected to be active well into future years. The extent to which inactive, but not yet abandoned operations will be included in the current control program will have been determined earlier in the subplan development process. Definitions of, and distinctions between, current and new operations, and applicability of differing levels of control to each should be set forth in the selected control subplan description.

Following formal implementation of the current source control subplan, continuing water quality management and WQM planning would be initiated (See Chapter 7.0). Continuing evaluation of the effectiveness of the control system in achieving its objectives and integration of WQM planning into pre-operations planning and mine-related permit approval functions would be a part of the continuing WQM process.

CHAPTER 4.0

MINE-RELATED BEST MANAGEMENT PRACTICES

4.1 Identification of BMP's In a Control System Context

State and areawide WQM agencies will often not be directly involved in design and application of the specific details of preventive measures and control practices or BMP's at individual mineral industrial operations sites. Instead, WQM agencies are responsible for assuring timely development, implementation, and continuing operation of an overall control system or process which is sufficiently effective to achieve water quality goals and protect beneficial water uses. Such a control system or regulatory process will include not only those components directly related to identification of specific preventive measures and control practices, but also all other elements that are needed to insure on-the-ground achievement of the control objectives. These elements include adequate legal authority (especially for industrial responsibility for all adverse hydrologic impacts during and following mining) strong enforcement, sufficient numbers of well qualified technical personnel, competent administration, sanctions for intentional violations, and other types of regulatory program support.

The WQM agency is responsible for developing a control system or a regulatory process which specifies or effectively identifies BMP's for each mine-related operation and insures that those preventive measures and control practices which are specified or identified are also in fact utilized. In some instances, specific details of mine-related field practice may apply so generally to all operations of a particular type, that their use is required directly in mine-related control law, or in subsequently issued rules and regulations. Across-the-board requirements for use of specific practices may also emerge if permitting greater flexibility for definition of site specific practice requirements under a permit process leads to abuses and ultimately to ineffective water pollution control.

4.2 Basic Objective and Approach to BMP Application

The basic objective for design and application of BMP's for mine-related industrial operations is:

> To recognize and sufficiently control the onsite and offsite pollution causing hydrologic consequences of mineral extraction and all other associated and supporting mine-related industrial operations so as to achieve water quality goals and protect beneficial water uses.

This basic objective can be achieved by applying general control principles to all mineral industrial operations within the framework of an effective regulatory control system or process. General control principles must be translated into specific preventive measures and control practices peculiar to the circumstances found at each mineral industrial operations site. This should result in attaining the desired level of control or the best practicable level of control.

The actual arrangements or approaches for carrying out this process are likely to vary from one area, or from one State to another. The mining industry will often play the biggest part in designing the specific details of preventive measures and control practices for use at each site, but with varying degrees of input and participation from government mine-related regulatory management agency personnel. In any event, design of specific control practices at each site should be accomplished by competent professionals who are knowledgeable about mine-related operations and prevention and control of water pollution.

4.3 General Control Principles and Examples of Specific Preventive Measures and Control Practices

Mineral industrial operations are so varied and diverse that no single list of control principles can include all the situations that might occur. However, this discussion of control principles touches upon the majority of the areas of mine-related pollution control.

Commercially mined and processed mineral commodities range from mineral fuels, such as coal and oil, to metallic ores of iron, copper, and numerous other metals, to nonmetallic minerals like sand and gravel, stone, phosphate, various clay minerals and others. A list of over 100 mineral industrial subcategories is found in Chapter 1.0., Section 1.2.

The varied types of mining include deep mining, strip mining, auger mining, open pit mining, placer mining and dredging, well extraction, solution mining, and others. Some of the various types of mining and phases of mineral industrial operations were described previously in Chapter 1.0, Section 1.4. Other phases of mineral industrial operations, in addition to mining, or mineral extraction itself, include mineral exploration, mineral transport, mineral processing, mineral storage, and mineral waste disposal. Each type of mineral industrial operation will have its own sequence of activities, and its own potential risk of water pollution during active operation and/or following close-down. Specific preventive measures and control practices must be designed for each different mineral industrial operation on the basis of a hydrologic examination of the site and the hydrologic consequences expected from all planned activities and sequenced operations (see Appendix A for an example of mine site hydrologic examination and Appendix B for a discussion of water quality implications of mine-related industry actions) This hydrologic examination involving recognition of hydrologic consequences and design of specific BMP's is an essential part of an effective pre-operations pollution control planning effort.

Whether conducted entirely by mining industry personnel or by various mixes of industry, and government, pre-planning for water pollution control must result in development of a control plan which will convince the government regulatory authority that the proposed mine-related industrial operation(s) can be conducted without causing surface water or ground water pollution that would interfere with beneficial water uses.

All adverse hydrologic consequences of mine-related industrial operations on surface water and ground water quality require examination and appropriate control. These may include some forms of hydrologic imbalance or disturbance, as well as direct chemical and/or physical pollution. Specific measures and practices must be designed to prevent or control all water pollution and beneficial water use impacts, including those stemming from both point and nonpoint sources. Proper selection and application of BMP's may provide at least a partially effective control mechanism for unregulated storm overflow from point source treatment systems. Storm overflow is exempted from compliance with effluent discharge limitations under NPDES.

Translation of general control principles into specific preventive measures and control practices involves identification or design of BMP's reflecting the best available prevention and control.

The U.S. Environmental Protection Agency published a report in October of 1973 entitled "Processes, Procedures and Methods to Control Pollution From Mining Activities" which was intended to provide a general overview of specific mine-related pollution control techniques, and to "point the direction for further detailed inquiry" by State and areawide WQM agencies, their designates, the mining industry and other parties.

The continuing mine-related water quality control and management process, which is discussed in Chapter 7.0, must provide for an ongoing evaluation of the effectiveness of the regulatory control system and the specific control practices being applied within its framework for meeting water quality goals and protecting beneficial water uses. As mine-related pollution control technology advances, the control system must recognize and insure implementation of improved and increasingly effective water pollution prevention and control practices as they become ready for practical field application.

4.3.1 Control Principles

General control principles which should be applied in selection and design of specific preventive measures and control practices are listed below.

1. Choose Least Hazardous Methods.

   Choose mine-related operating methods which minimize pollution causing hydrologic disturbance and which generate the least potential water pollution hazard (see page 4-9).

2. Manage Water.

   Plan mineral industrial operations so as to manage water entering, moving through, and exiting from all affected surface or subsurface areas. Proper water management often includes minimizing inflow of surface water or ground water into affected areas (see page 4-13).

3. Control Erosion and Trap Sediment.

   Use the best combination of at-source erosion and sediment control techniques to control erosion and sediment loss from all affected and disturbed areas and to prevent offsite transport (see page 4-16).

4. Segregate Water From Toxics.

   Reduce the amount of water and the length of time that water comes into contact with pollution forming materials; toxic, acid forming, etc. (see page 4-18).

5. Collect and Treat Runoff When Other Approaches Fail.

   Consider collection and treatment of nonpoint source runoff, seepage, and percolation when other at-source control approaches prove to be inadequate to achieve control objectives (see page 4-20).

6. Quickly Stabilize Disturbed Areas.

   Stabilize and protect all disturbed areas which present a potential for contributing pollutants as contemporaneously as possible with conduct of mine-related industrial operations, including mineral exploration, mine development, extraction, transport, processing, storage, and waste disposal (see page 4-22).

7. Properly Store Minerals and Dispose of Mineral Wastes.

   Store mined minerals and processed mineral products, and dispose of all mineral wastes so that pollution of surface water and ground water by wind action, runoff, seepage or percolation (leaching) is effectively prevented or controlled (see page 4-24).

8. Correct Pollution-Causing Hydrologic Disturbances.

   Use measures designed to restore premining hydrologic conditions or to correct hydrologic disturbances which may be responsible for causing surface water or ground water pollution or adverse beneficial use impacts during or following mine-related operations (see page 4-28).

9. Prevent and Control Pollution From Roads.

   Insure that access and haul roads are constructed, maintained, and closed so as to control or prevent water pollution related to mass movements, erosion, and offsite transport of sediment (see page 4-31).

10. Avoid Disturbing Stream Beds, Stream Banks and Natural Drainways.

    Avoid disturbing or constructing roads within stream beds, banks or natural drainways and drainage channels, or using such drainages for vehicular access (see page 4-36).

11. Use Stringent Controls in High Risk Areas.

    Recognize particularly high risk pollution hazard situations and sensitive areas, and design especially stringent preventive measures and control practices which are adequate to prevent or control pollution under these circumstances. Such special situations might include mine-related operations conducted: on alluvial valley floors; on steep slopes; within areas draining to existing high quality waters which constitute an outstanding National resource; within municipal watersheds or sole source aquifer recharge zones recognized under Subsection 1424(e) of

Public Law 93-523, "Safe Drinking Water Act"; where water quality or hydrologic consequences may adversely affect rare and endangered species (see page A-38).

12. Apply Sound Engineering.

Insure use of proper engineering design for all mine-related structures which present a risk of pollution through design fault or failure, including retainment dike walls, pipelines, cut and fill slopes, dams, impoundments, and mineral storage and waste disposal piles (see page 4-45).

13. Properly Locate and Seal Shafts and Boreholes.

Locate, fill, case, seal, or otherwise manage all boreholes, wells, shafts, and portals so as to prevent or control surface water and ground water pollution (see page 4-47)

14. Control Fugitive Dust

Fugitive dust may result from any affected area or from any phase of any mineral industrial operation. Dust should be controlled when it contributes to chemical or physical water pollution. Particular attention should be given to control of wind blown fines containing toxic or radioactive contaminants (see page 4-50).

15. Maintain Control Measures.

Perform all maintenance necessary to insure the continued effectiveness of all control measures including drainage structures and treatment systems (see page 4-52).

16. Use Temporary Stabilization and Control When Needed.

Use temporary stabilization and control measures when transitory conditions are created during conduct of mine-related industrial operations, which present a significant water pollution hazard, including those created during periods of inactivity (see page 4-55).

17. Prevent and Control Pollution After Close Down or Abandonment.

Close down, remove or abandon all structural measures, facilities and areas affected by mine-related industrial operations upon completion of activity so as to prevent or control long term postoperational surface water and ground water pollution (see page 4-57).

4.3.2 Example Preventive Measures and Control Practices

Each control principle is illustrated on the pages following by one specific example of a practice, procedure, method, measure, or technique used within some particular mineral industrial subcateogory. Illustrative examples have been taken largely without modification from EPA publications, from State mining regulations and from recent Federal coal mining legislation, now Public Law 95-87, dated August 3, 1977.

CONTROL PRINCIPLE NO. 1

CHOOSE LEAST HAZARDOUS METHODS

Choose mine-related operating methods which minimize pollution causing hydrologic disturbance and which generate the least potential water pollution hazard.

EXAMPLE

DOWNDIP MINING AND PREPLANNED FLOODING

Take from: "Processes, Procedures and Methods to Control Pollution from Mining Activities". p. 188-191. Environmental Protection Agency, EPA 430/9-73-011. October 1973.

Most pollution forming materials require oxidation for increased solubility. The sulfides which are responsible for most pollution are relatively insoluble and inert until oxidized. Underground mining provides a source of oxygen to these minerals, which have only limited oxygen contact prior to mining. If a mine contains air after abandonment, then the minerals will continue to oxidize. Flooding of a mined zone is the only practical method of eliminating the oxygen source under present technology. Elimination of free air atmosphere greatly reduces oxidation. Ground water entering a mine will have a small amount of dissolved oxygen: on the order of 0 to 10 mg/l. This supply is insufficient to sustain any significant amount of pollution formation. Flooding is not always the best solution, because some minerals will be dissolved under acidic conditions, which are likely to occur during flooding.

Free air oxygen is not always required for oxidation. For example, pyrite can be oxidized by ferric ions. The extent of this type of reaction is unknown. Most literature sources seem to indicate the elimination of free air oxygen will eliminate a large portion of pollution production. This means that oxidation is insignificant without the presence of free air oxygen.

Underground mines can be developed so that either flooding or zero discharge will occur after completion of mining. This merely requires positioning the openings at the highest elevation and developing the mine in a downward direction. The openings do not always have to be in the highest position if sealing is planned. The elevation difference between the openings and the highest elevation of a mine should be held to a minimum to insure effective operation of the seal. The seal and the rock in the seal area should be capable of withstanding the maximum attainable water pressure.

Study of local hydrogeological conditions may reveal that the mine could never be fully flooded. In these cases, discharge can be minimized by locating the mine opening above the highest attainable post mining water level.

Flooding cannot occur unless an entire mine area is capable of withstanding imposed water pressure. Consideration must be given to the fact that the seal area may not be the weak point. The down dip outcrop area, and points where mining approached the land surface, are potential weak spots. These areas could physically fail under high water pressures.

Failure is not the only problem. The rock units may have enough permeability that a significant discharge will occur under the increased head. Sufficient mineral barriers should remain along the perimeter of a mine to insure flooding. Consideration should always be given relative to closeness of approach to the land surface at any given area. Mineral barriers should also remain between adjacent underground mines to prevent interflow from compounding problems.

This system basically utilizes down dip mining with appropriate mineral barriers in place.

Most underground mines were developed to the rise of the mineral wherever there was a choice of going to the rise or to the dip. This was done to facilitate gravity drainage from the mine. It also allowed full mine cars to exit the mine under gravity influence, and the empty cars were then hauled uphill. The majority of abandoned underground coal mines in the eastern United States were developed to the rise. These mines are large sources of pollution and they are extremely difficult to seal. If downdip mining had been practiced, along with judicious use of mineral barriers, a large portion of the acid mine drainage problem we now face would never have occurred.

Use of this technique will entail additional costs for underground mining. Water will collect in low spots and will have to be pumped from the mine. Pumping costs will vary greatly. They can be prohibitive at times, as evidenced by the decline of underground mining in the Pennsylvania Anthracite Field. Leaving mineral barriers in place will cause additional costs because the barriers consist of non-recoverable mineral.

CONTROL PRINCIPLE NO. 2

MANAGE WATER

Plan mineral industrial operations so as to manage water entering, moving through, and existing from all affected surface or subsurface areas. Proper water management often includes minimizing inflow of surface water or ground water into affected areas.

EXAMPLE

WATER DIVERSION

Taken from: "Processes, Procedures and Methods to Control Pollution from Mining Activities", p. 63-66. Environmental Protection Agency, EPA 430/9-73-011, October 1973.

Water diversion involves collection of water before it enters the mine area, and then conveying it around a mine site. This procedure decreases erosion, reduces pollution and reduces water treatment costs by reducing the volume of water that needs to be treated.

Ditches, flumes, pipes, trench drains and dikes are all commonly used for water diversion. Ditches are usually excavated upslope of the surface mine to collect and convey the water. Flumes and pipes are used to carry water down steep slopes or across regraded areas. Riprap and dumped rock are sometimes used to reduce water velocity in the conveyance system.

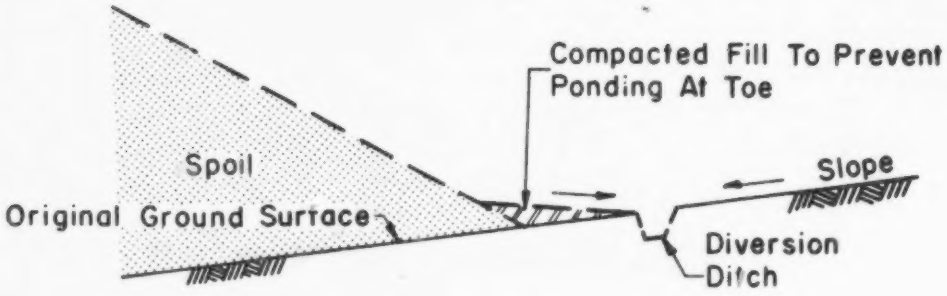
Water diversion can also occur within a surface mine. Drainways at the bottom of a highwall are helpful, in many cases, to convey entering ground water from the mine prior to its contact with pollution-forming materials.

Ground waters can be diverted by pumping water from the flow path area prior to entrance to the mine. In some instances, it may be cheaper to drill holes and pump ground water away than to treat the water after it passes through a mine.

Surface water diversion could be applied to many large valley fill bony piles in the east and tailings piles in the west. Many of these waste piles were built across valleys (natural watercourses) causing streams to pass through the pollution-forming materials. This water can be diverted around or conveyed through the waste material.

Surface water diversion is an effective technique for reducing water pollution. It can be applied to almost any surface mine or mine waste pile.

A water diversion system should be properly designed to accommodate expected volumes and water velocities. If the capacity of a ditch is exceeded, water can erode the sides and render the ditch useless for any amount of rainfall.


Compacted Fill To Prevent Ponding At Toe
Spoil
Slope
Original Ground Surface
Diversion Ditch

CROSS SECTION OF
DRAINAGE DITCH ON UPHILL SIDE OF A SPOIL PILE

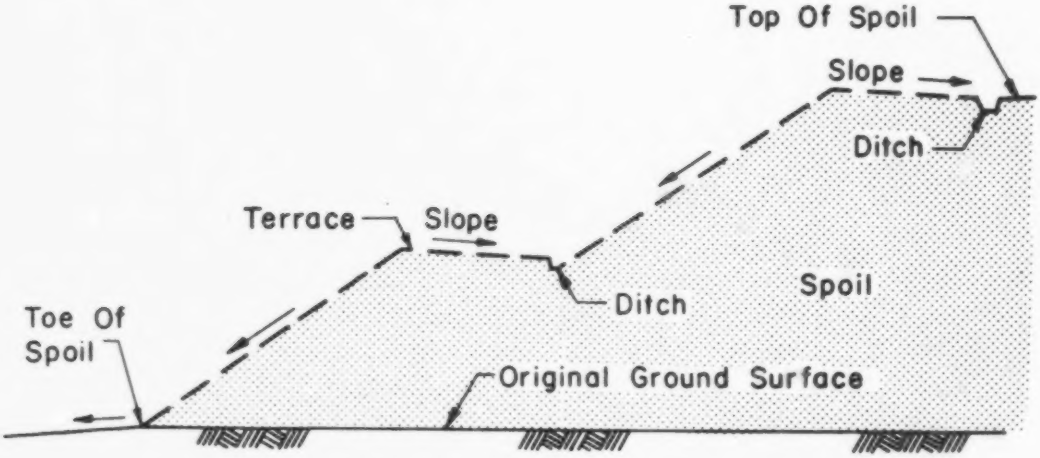

Top Of Spoil
Slope
Ditch
Terrace
Slope
Ditch
Spoil
Toe Of Spoil
Original Ground Surface

FIGURE 4.1· CROSS SECTION OF
DIVERSION DITCH APPLICATIONS

CONTROL PRINCIPLE NO. 3

CONTROL EROSION AND TRAP SEDIMENT

Use the best combination of at-source erosion and sediment control techniques to control erosion and sediment loss from all affected and disturbed areas and to prevent offsite transport.

EXAMPLE

ONSITE EROSION CONTROL

Taken from: "Drainage System: Ditch on Bench." West Virginia Department of Natural Resources Surface Mining Reclamation Regulations, Chapter 20-6, Series VII, Section 7.0, Subsection 7A.02.

"Drainage ditches will be constructed on the excavated solid bench in order to carry off storm, surface or seepage water . . . . In no case shall water be discharged over a spoil slope. Removal of water from the bench shall be accomplished by use of adequate pipe, a rock riprap flume, asphalt or concrete shutes, or by grading a channel to nonerosive rock."

CONTROL PRINCIPLE NO. 4

SEGREGATE WATER FROM TOXICS

Reduce the amount of water and the length of time that water comes into contact with pollution forming materials; toxic, acid forming, etc.

EXAMPLE

SPECIAL HANDLING AND PLACEMENT OF ACID FORMING MATERIALS

Take from: "MINE DRAINAGE". Pennsylvania Department of Environmental Resources Rules and Regulations, Title 25, Part I, Subpart C, Article II, Chapter 99 .36(c)(1). September 2, 1971.

"Acid-forming materials shall be separated from the rest of the spoil and spread along the bottom of the pit close to the base of the spoil pile along the low-wall side of the cut. All exposed refuse shall be covered with clean fill daily if necessary to prevent pollution, but at least at intervals not to exceed one week. The top surface of the cover shall be graded so that water will run off rather than soak into the backfill to reach the acid-forming refuse. Alternate layers of refuse and clean fill shall be spread over the area so that the maximum thickness of each layer of refuse shall be no greater than 30 inches and the minimum thickness of each layer of clean fill shall be no less than 24 inches. The top layer of refuse shall have a cover of clean fill with a minimum thickness of five feet. The cover shall be graded so that surface water will drain away from the disposal area until such time as the area has been completely restored."

CONTROL PRINCIPLE NO. 5

COLLECT AND TREAT RUNOFF WHEN OTHER APPROACHES FAIL

Consider collection and treatment of nonpoint source runoff, seepage, and percolation when other at-source control approaches prove to be inadequate to achieve control objectives.

EXAMPLE

UNDERDRAINS

Take from: "Processes, Procedures and Methods to Control Pollution from Mining Activities", p. 67. Environmental Protection Agency, EPA 430/9-73-011. October 1973.

DESCRIPTION

Underdrains of rock or perforated pipe can be placed below pollution-forming materials to quickly discharge infiltrating water. These devices shorten the flow path and residence time of water in the waste materials. Underdrains are designed to provide zones of high permeability to collect and transport water from the bottom of the piles. A common method of construction is to use trenches filled with rock.

Underdrains should prove effective for use with bony storage areas and large tailings accumulations. They are best suited for installation prior to creation of the pile. They can also be installed in existing piles, although the cost is higher.

EVALUATION

These drains have been tried on western tailings piles, but their effectiveness has not been documented. They are recommended for use with the head-of-hollow mining technique. The concept is theoretically sound and will probably be demonstrated in the near future.

There are certain limitations to use of underdrains. They should not be used where inundation has occurred, because they will drain the pile and cause an adverse effect. They should only be used in piles where the water table is fluctuating, and flow is in direct response to rainfall. Care must be taken during design to preclude the possibility of fines clogging the completed underdrain installation.

The water quality of flow from underdrains should be monitored and appropriate effluent discharge limitations met through direct treatment when necessary.

CONTROL PRINCIPLE NO. 6

QUICKLY STABILIZE DISTURBED AREAS

Stabilize and protect all disturbed areas which present a potential for contributing pollutants as contemporaneously as possible with conduct of mine-related industrial operations, including mineral exploration, mine development, extraction, transport, processing, storage, and waste disposal.

EXAMPLE

CONTEMPORANEOUS STABILIZATION OF AFFECTED AREAS

(Take from: "Environmental Protection Performance Standards". Public Law 95-87. Surface Mining Control and Reclamation Act of 1977, Section 515(b)(4) and (16). August 3, 1977

"General performance standards shall be applicable to all surface coal mining and reclamation operations and shall require the operation as a minimum to-

- o stabilize and protect all surface areas including spoil piles affected by the surface coal mining and reclamation operation to effectively control erosion and attendant air and water pollution;
- o insure that all reclamation efforts proceed in an environmentally sound manner and as contemporaneously as practicable with the surface coal mining operations.'

CONTROL PRINCIPLE NO. 7

PROPERLY STORE MINERALS AND DISPOSE OF MINERAL WASTES

Store mined minerals and processed mineral products, and dispose of all mineral wastes so that pollution of surface water and ground water by wind action, runoff, seepage or percolation (leaching) is effectively prevented or controlled.

EXAMPLE

REDUCING SURFACE WATER INFILTRATION

Take from: "Processes, Procedures and Methods to Control Pollution from Mining Activities", p. 57-59. U.S. Environmental Protection Agency, EPA 430/9-73-011. October 1973.

This technique involves reducing surface permeability of pollution-forming materials. This can be achieved by placement of impervious materials such as concrete, soil cement, asphalt, rubber, plastic, latex and clay. This effect can also be achieved by surface compaction and by chemical surface treatment (such as carbonate bonding).

Concrete and asphalt are applied in a layer on the pollution-forming material to form a water tight seal. The remaining materials may be left exposed, or may be covered with soil, depending upon the material and future land use.

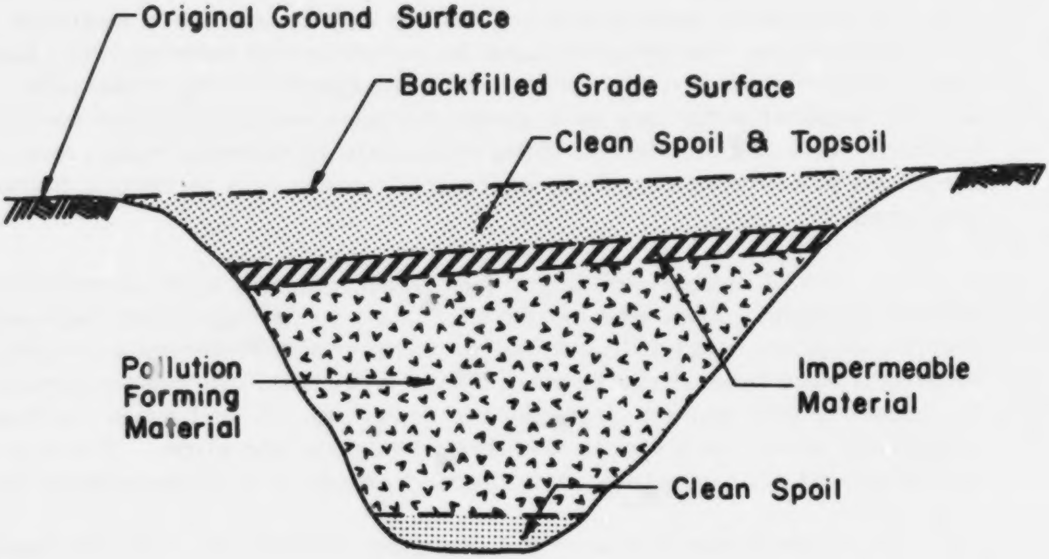

Original Ground Surface
Backfilled Grade Surface
Clean Spoil & Topsoil
Pollution Forming Material
Impermeable Material
Clean Spoil

FIGURE 4.2-REDUCING SURFACE WATER INFILTRATION TO BURIED POLLUTION - FORMING MATERIAL

Compaction of the existing surface materials will decrease infiltration to some degree. Degree of success will depend on the physical nature of the material and equipment utilized for compaction.

Latex soil sealant is applied as a dry compound at a predetermined depth in existing surface material. The latex compound reacts with infiltrating ground water to form a thin, impermeable film, or layer, at a desired depth.

Carbonate bonding is a physio-chemical application to an existing surface which produces a cement-like product. The procedure involves roto-tilling lime hydrate and water into the material, followed by installation of plastic perforated pipes. The pipes distribute pure carbon dioxide gas through the lime hydrate-waste material mixture, converting the lime hydrate into a hard carbonate material which acts as a surface sealant.

Asphalt and concrete are excellent sealants, but are expensive. The only presently economically feasible way to use these sealants is in multipurpose reclamation such as constructing parking lots, buildings, airport runways and roads over pollution-forming materials. They are too expensive for use as a single purpose water pollution control method. Use of pollution-forming materials in highway road base construction to eliminate surface water infiltration is a technique being researched.

Use of rubber and plastic as coverings has been accomplished experimentally. They are extremely prone to damage when exposed, and do not appear feasible without an extensive maintenance program. Attempts have been made to cover them with soil, but the equipment used to place the soil usually damages the covering. A soil cover on these materials is not very stable and tends to erode and slide. The soil coverings would also vegetate, which could result in root damage to the seals.

Compaction is one of the cheapest techniques, but unfortunately most mine wastes cannot be compacted sufficiently (without use of other techniques) to significantly control water pollution.

Carbonate bonding is essentially in the experimental stages. However, it shows promise of being a viable sealing technique. Further experimentation in practical situations should be performed before extensive use of the technique.

Use of latex as a soil sealant proved ineffective in a demonstration project in Clearfield County, Pennsylvania.

Clay appears to be the best practical sealant material. It is one of the least expensive and yet most maintenance free. Clay is compacted over the pollution-forming material, and should be covered with soil to prevent desiccation, failure, and subsequent erosion. Feasibility of clay as a sealer usually depends on local availability of clay.

Pollution-forming materials should be graded into the smallest practical area prior to sealing.

All of these sealants are subject to failure, either chemical or physical, and will require some maintenance.

CONTROL PRINCIPLE NO. 8

CORRECT POLLUTION-CAUSING HYDROLOGIC DISTURBANCES

Use measures designed to restore premining hydrologic conditions or to correct hydrologic disturbances which may be responsible for causing surface water or ground water pollution or adverse beneficial use impacts during or following mine-related operations.

EXAMPLE

REGRADING TO APPROXIMATE ORIGINAL CONTOUR

Taken from: "Processes, Procedures and Methods to Control Pollution from Mining Activities", p. 112-113. U.S. Environmental Protection Agency, EPA 430/9-73-011. October 1973.

DESCRIPTION

This technique involves regrading a mine to a shape that closely resembles original land contour. It is generally one of the most favored regrading techniques because it returns the land as closely as possible to its pre-mining state. This technique is also favored because all spoil is placed back into the mine resulting in less disturbed area, and usually less water pollution. Contour regrading facilitates deep burial of pollution-forming material. It reduces erosion due to reduction in size of disturbed areas.

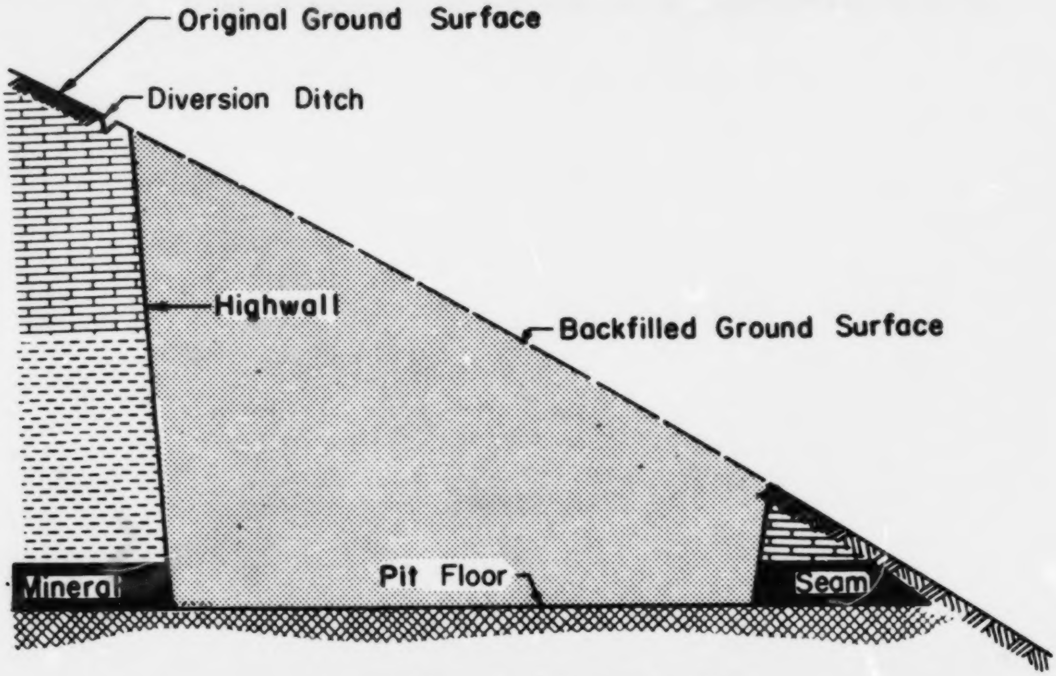

Original Ground Surface
Diversion Ditch
Highwall
Backfilled Ground Surface
Mineral
Pit Floor
Seam

FIGURE 4.3 - CROSS SECTION OF TYPICAL CONTOUR BACKFILL

EVALUATION

Contour regrading appears to be one of the best methods of water pollution control for surface-mined lands. It is also one of the most expensive, because of the large volume of spoil to be moved. It can be facilitated through use of mining techniques such as the modified block cut.

Contour regrading is difficult at abandoned strip mines in steep terrain. It is difficult and expensive to move downslope spoil back upslope onto the bench.

Contour regrading is limited to areas where sufficient spoil exists to achieve original contour. It is not applicable for mining reclamation where there is a large volume of mineral in relation to the volume of overburden, as in open pit or quarry mining.

CONTROL PRINCIPLE NO. 9

PREVENT AND CONTROL POLLUTION FROM ROADS

Insure that access and haul roads are constructed, maintained, and closed so as to control or prevent water pollution related to mass movements, erosion, and offsite transport of sediment.

EXAMPLE

HAUL ROAD CULVERT OUTFLOW TRANSPORT TO TOE OF SLOPES

Taken from: "Demonstration of Coal Mine Haul Road Sediment Control Techniques", p. 34-37. U.S. Environmental Protection Agency, EPA-600/2-76-196. August 1976.

Section and flexible slope drains can be used to channel culvert outflows so as to stabilize areas at the toe of the fill slope; however, freezing weather presents some maintenance problems for flexible downdrains. Culvert pipe buried in the fill slope would probably require the least maintenance.

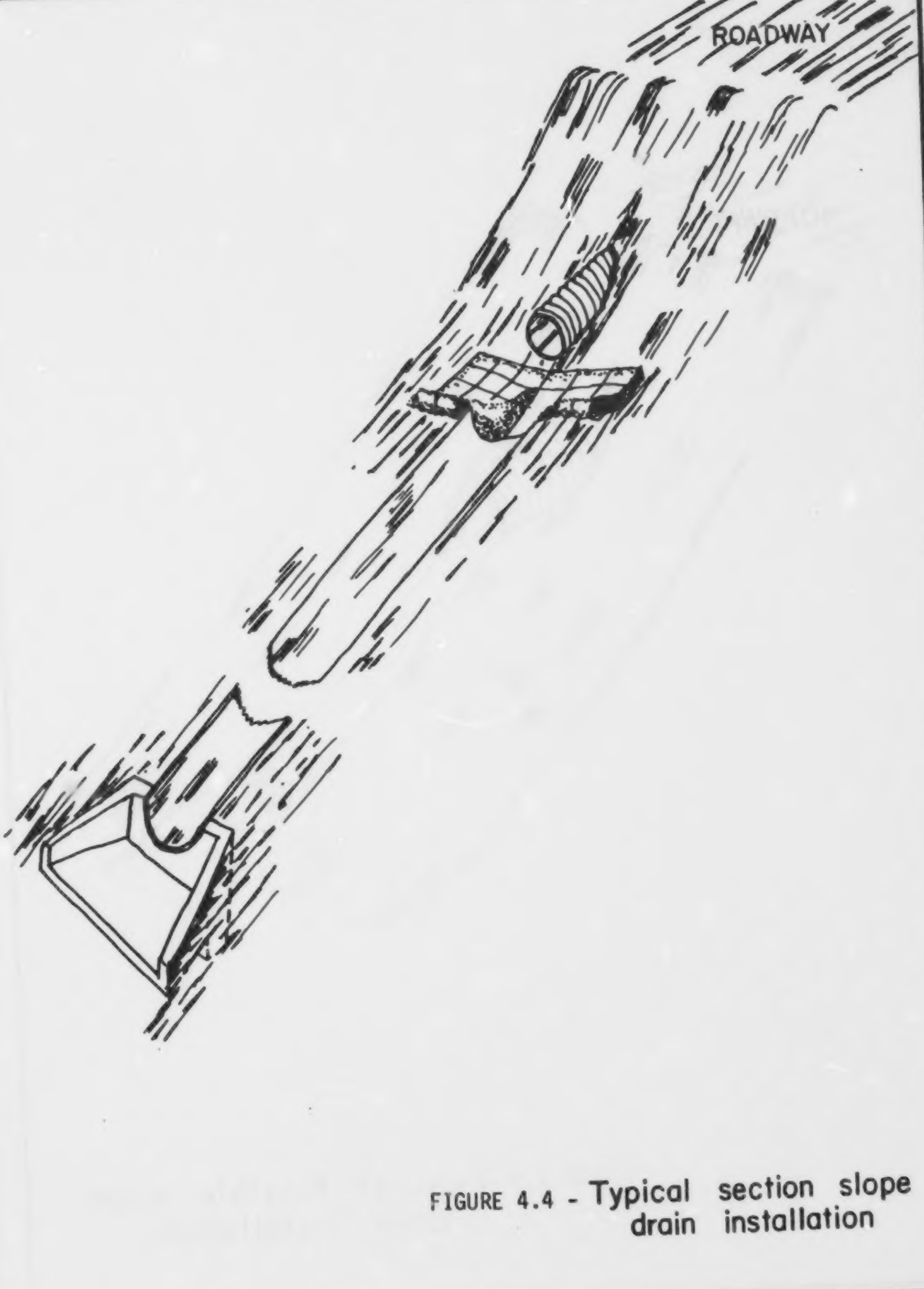


FIGURE 4.4 - Typical section slope drain installation

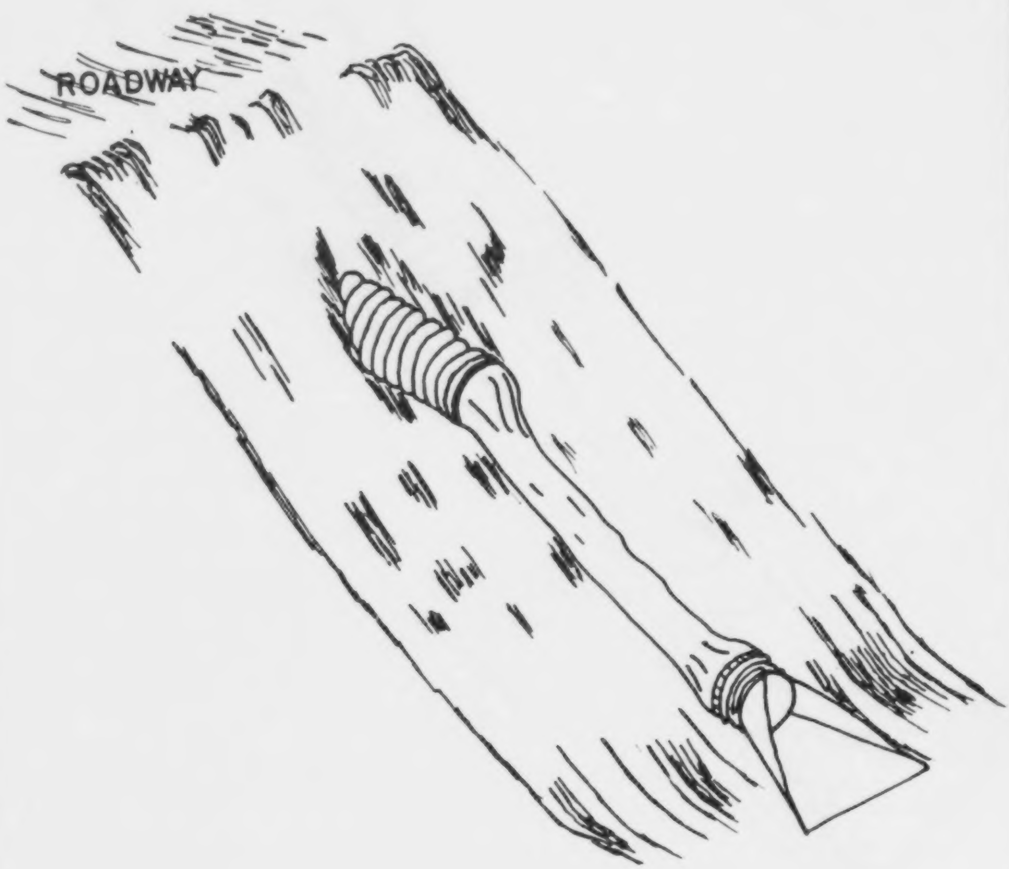


FIGURE 4.5 -Typical flexible slope drain installation

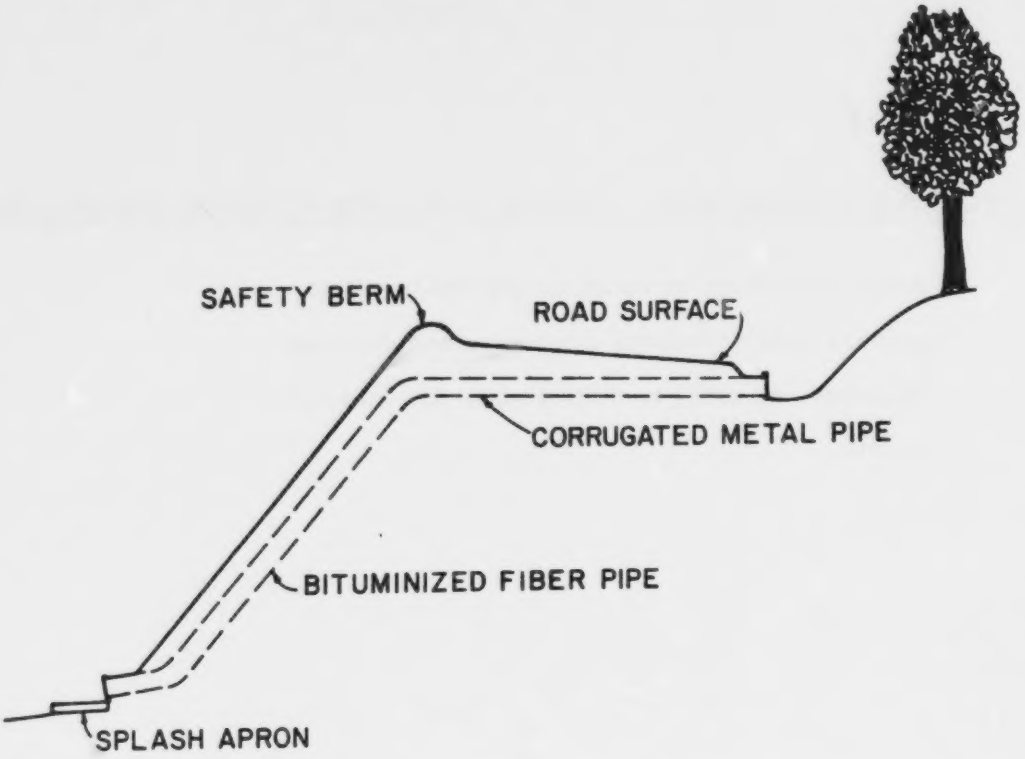

SAFETY BERM
ROAD SURFACE
CORRUGATED METAL PIPE
BITUMINIZED FIBER PIPE
SPLASH APRON

FIGURE 4.6-Typical installation of pipe buried in fill slope

CONTROL PRINCIPLE NO. 10

AVOID DISTURBING STREAM BEDS, STREAM BANKS AND NATURAL DRAINAGES

Avoid disturbing or constructing roads within stream beds or natural drainways and drainage channels, or using such drainages for vehicular access.

EXAMPLE

NATURAL DRAINWAY DISTURBANCE LIMITATION

Take from: "Natural Drainways". West Virginia Department of Natural Resources Surface Mining Reclamation Regulations, Chapter 20-6, Series VII, Section 7.02. 1971.

"Natural drainways in the area of land disturbed by surface mining operations shall be kept free of overburden except where overburden placement has been approved. Such drainways shall be identified on the maps submitted with the application. Surface mining operations will be prohibited 50 feet on either side of a natural drainway."

CONTROL PRINCIPLE NO. 11

USE STRINGENT CONTROLS IN HIGH RISK AREAS

Recognize particularly high risk pollution-hazard situations and sensitive areas, and design especially stringent preventive measures and control practices which are adequate to prevent or control pollution under these circumstances. Such special situations might include mine-related operations conducted: on alluvial valley floors; on steep slopes; within areas draining to existing high quality waters which constitute an outstanding National resource; within municipal watersheds or sole source aquifer recharge zones recognized under Subsection 1424(e) of Public Law 93-523, "Safe Drinking Water Act"; where water quality or hydrologic consequences may adversely affect rare and endangered species.

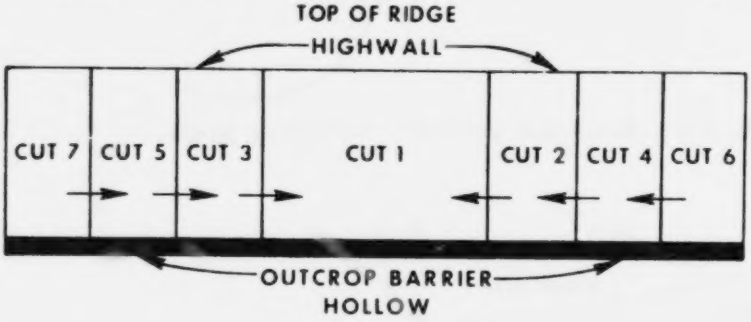
EXAMPLE

BLOCK-CUT OR HAUL BACK METHOD OF CONTOUR SURFACE MINING ON STEEP SLOPES

Taken from: "Environmental Protection in Surface Mining of Coal", p. 74-80. U.S. Environmental Protection Agency, EPA-670/2-74-093. Oct. 1974.

The Block-cut method (haul back, pit storage, put and take, etc.) is a simple innovation of the conventional contour strip mining method for steep terrain (See Figure 4.7). Instead of casting the overburden from above the coal seam down the hillside, it is hauled back and placed in the pit of the previous cut. The method is not new and is known by various names, depending on the locality. Basically, the operational procedures are similar in that no spoil is deposited on the downslope below the coal seam, topsoil is saved, overburden is removed in blocks and deposited in prior cuts, the outcrop barrier is left intact, and reclamation is integrated with mining (Figures 4.8 and 4.9).

When beginning the mine, a block of overburden is removed down to the coal seam and disposed of (Figure 4.7). This first cut spoil can be placed above the highwall in some instances, or spread along the downslope as in conventional contour mining, or moved laterally and deposited in a head-of-hollow fill or ridge fill. The original cut is made into the hillside to the maximum depth that is to be mined. The width is generally three time that of the following cuts. After the coal is removed, the overburden from the second cut is placed in the first pit and the coal from the second cut is removed. This process is repeated as mining progresses around the mountain. Once the original cut has been made, mining can be continuous, working in both directions around the hill or in only one direction.



PROCEDURE:

1 SCALP FROM TOP OF HIGHWALL TO OUTCROP BARRIER, REMOVE AND STORE TOPSOIL.
2 REMOVE AND DISPOSE OF OVERBURDEN FROM CUT 1.
3 PICK UP COAL, LEAVING AT LEAST A 15 FOOT UNDISTURBED OUTCROP BARRIER.
4 MAKE SUCCESIVE CUTS AS NUMBERED.
5 OVERBURDEN IS MOVED IN THE DIRECTION, AS SHOWN BY ARROWS, AND PLACED IN THE ADJACENT PIT.
6 COMPLETE BACKFILL AND GRADING TO THE APPROXIMATE ORIGINAL CONTOUR.

Figure 4.7 -Block-cut method.

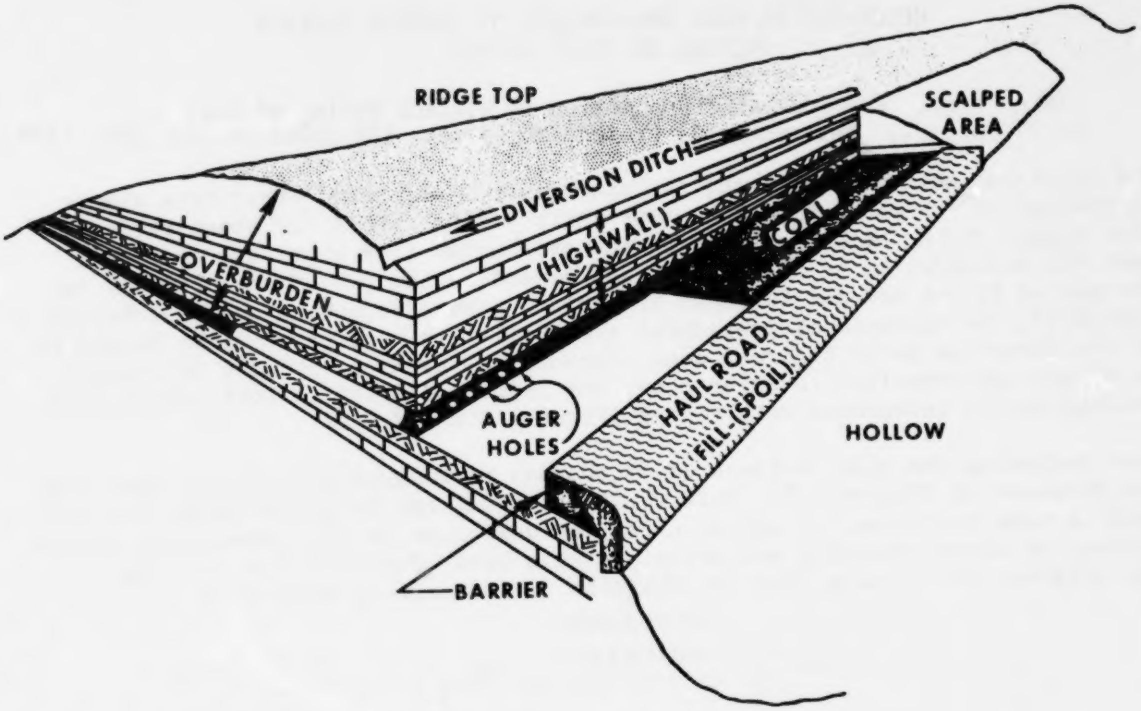

RIDGE TOP
SCALPED AREA
DIVERSION DITCH
OVERBURDEN
(HIGHWALL)
COAL
AUGER HOLES
HAUL ROAD
FILL-(SPOIL)
HOLLOW
BARRIER

FIGURE 4.8- Block-cut method: Stripping phase.

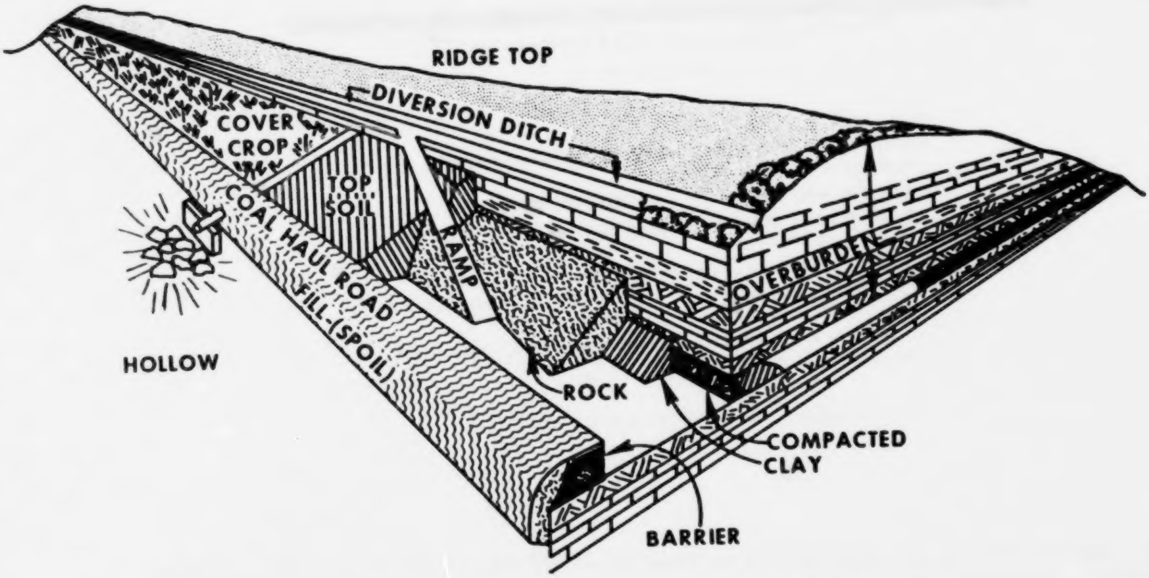

RIDGE TOP
DIVERSION DITCH
COVER CROP
TOP SOIL
RAMP
COAL HAUL ROAD
FILL-(SPOIL)
OVERBURDEN
HOLLOW
ROCK
COMPACTED CLAY
BARRIER

FIGURE 4.9 - Block-cut method: Backfilling phase.

The cuts are mined as units, thereby making it easier to retain the original slope and shape of the mountain after mining. In all cuts, an unmined outcrop barrier is left to serve as a notch to support the toe of the backfilled overburden. Block-cut mining makes it possible to mine on slopes steeper than those being mined at present without the danger of slides and with minimal disturbance. Approximately 60% less total acreage is disturbed than by other mining techniques now in use. There is significant visual evidence that the block cut method is less damaging than the old practice of shoving overburden down the side of the mountain resulting in permanent scars on the landscape. The treeline below the mined area and above the highwall is preserved. Results of the mining operation generally are hidden and cannot be seen from the valley below. This cosmetic feature is only one of the advantages that contribute to making this an acceptable steep-slope mining method.

Using hypothetical costs, Secor calculated that under Pennsylvania law, where backfilling must be to the original contour, the block-cut method cost 33 cents per ton less than the conventional method. He presumes that the lower cost was due to the fact that conventional pull-back methods involve double handling of spoil material. Secor cautions that although the block cut method is no more expensive and may be less than conventional dragline pull-back mining, these costs are estimates only and can vary from operation to operation.

Existing or pending State and Federal legislation makes it illegal to push overburden beyond the outcrop and over the mountainside and thus bans the conventional type of contour strip mining. However, the block cut or similar methods meet the criteria of this new legislation and allow for recovery of coal reserves in mountainous regions that would otherwise be unmineable.

West Virginia Reclamation Chief, Benjamin C. Greene has stated the following about the block-cut method: "As far as we're concerned it's the way of the future if we are to continue contour surface mining . . . The environmental effects are very minimal and can be totally controlled by this mining method."

The block-cut method is no longer experimental and is now operational in several States. Enough information is available from active operations to show this method to be potentially feasible from an economic and environmental standpoint.

Benefits and advantages of the block-cut method over conventional contour strip-mining have been demonstrated at producing mines under varying conditions and are:

1. Spoil on the downslope is totally eliminated. Since no fill bench is produced, landslides have been eliminated.

2. Mined area is completely backfilled, and since no highwall is left, the area is aesthetically more pleasing.

3. Acreage disturbed is approximately 60% less than that disturbed by conventional contour mining.

4. Reclamation costs are lower, as the overburden is handled only once instead of two or three times.

5. Slope is not a limiting factor.

6. The block-cut method is applicable to multi-seam mining.

7. Size of the disturbed area drainage system is smaller.

8. Size and number of sediment control structures have been reduced. Total life of structure usefulness is increased.

9. Revegetation costs have been considerably reduced and it is easier to keep the seeding current with the mining. Bond releases are quicker.

10. AMD siltation, and erosion is significantly reduced and more easily controlled because of concurrent reclamation with mining.

11. Overburden is easily segregated, topsoil can be saved, and toxic materials can be deeply buried.

One of the disadvantages of the block-cut method is:

> Long-term environmental consequences are not known and will require a monitoring program of a pilot block-cut operation to determine if stream siltation and mineralization can be eliminated.

Perhaps the most salient feature of block cutting is that the removal of the overburden and the reforming of the original contour by backfilling are integral processes (Figures 4.10 and 4.11). As a result, the method tends to reduce many of the associated environmental impacts that occur by other methods. This new mining technique has been accepted as one of the most significant breakthroughs made in contour mining in mountainous terrain.

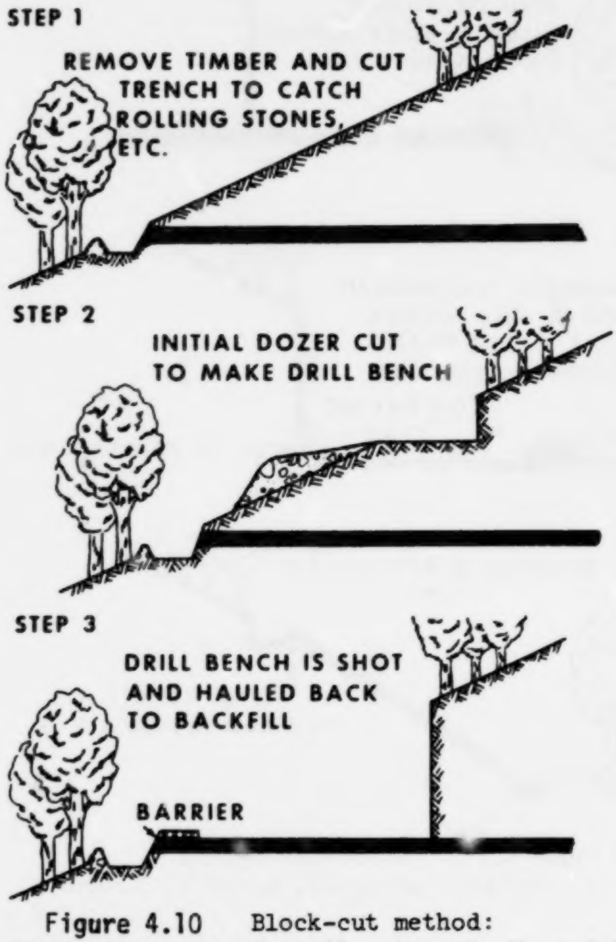

STEP 1
REMOVE TIMBER AND CUT TRENCH TO CATCH ROLLING STONES, ETC.
STEP 2
INITIAL DOZER CUT TO MAKE DRILL BENCH
STEP 3
DRILL BENCH IS SHOT AND HAULED BACK TO BACKFILL
BARRIER

Figure 4.10 Block-cut method:
Controlled placement of spoil, steps 1, 2, and 3.

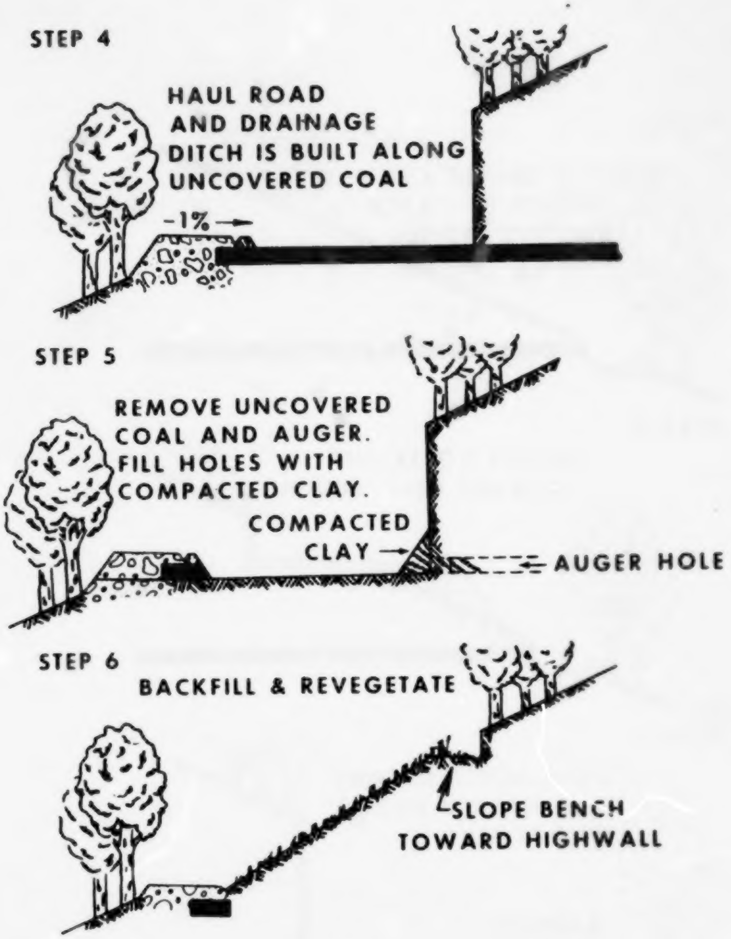

STEP 4
HAUL ROAD AND DRAINAGE DITCH IS BUILT ALONG UNCOVERED COAL
-1%
STEP 5
REMOVE UNCOVERED COAL AND AUGER. FILL HOLES WITH COMPACTED CLAY.
COMPACTED CLAY
AUGER HOLE
STEP 6
BACKFILL & REVEGETATE
SLOPE BENCH TOWARD HIGHWALL

Figure 4.11 - Block-cut method:
Controlled placement of spoil, steps 4, 5, and 6.

CONTROL PRINCIPLE NO. 12

APPLY SOUND ENGINEERING

Insure use of proper engineering design for all mine-related structures which present a risk of pollution through design fault or failure, including retainment dike walls, pipelines, cut and fill slopes, dams, impoundments, and mineral storage and waste disposal piles.

EXAMPLE

TEMPORARY SEDIMENT BASIN ANTI-SEEP COLLAR DESIGN

Taken from: "Erosion and Sediment Control-Surface Mining in the Eastern U. S." Volume 2: Design, p. 59-63. U.S. Environmental Protection Agency Technology Transfer Seminar Publication. October 1976.

Anti-Seep Collar Design

This procedure provides the anti-seep collar dimensions only for temporary sediment basins in order to increase the seepage length by 10 percent for various pipe slopes, embankment slopes, and riser heights. This does not apply to permanent structures, which must have an increase of 15 percent in the seepage length.

The first step in designing anti-seep collars is to determine the length of pipe within the saturated zone of the embankment. This can be done graphically or by the following equation, assuming that the upstream slope of the embankment intersects the invert of the pipe at its upstream end. See embankment-invert intersection on figure I-25.[1/]

$$L_s = y\,(z+4)\left[1+\frac{\text{pipe slope}}{0.25\text{-pipe slope}}\right]$$

where:

L_s = Length of pipe in the saturated zone (ft.)

y = Distance from upstream invert of pipe to highest normal water level expected to occur during the life of the structure, usually the top of the riser (ft.).

z = Slope of upstream embankment as a ratio of z ft. horizontal to 1 foot vertical.

pipe slope = Slope of pipe in feet per foot.

[1/] The numbers 4 and 0.25 are based on approximation of the phreatic line (4:1 — figure I-25).

To determine L_s graphically, refer to figure I-26.[1/] The number, size, and spacing of collars can then be determined from figure I-27.[1/]

Example — Given: y = 8 ft., embankment slope = 2.5:1,
pipe slope = 10%, pipe diameter = 36"

Find: number, size, and spacing of anti-seep collars.

From figure I-26,[1/] saturated length, L_s = 87 ft. From figure I-27,[1/] the size for two collars would be 7.3 ft. and for three collars, 5.9 ft. Select two collars since they would be less expensive and easier to install. Collar sizes should be given in feet and inches; therefore, use two collars 7 ft 4 in x 7 ft 4 in. From figure I-27,[1/] the projection is 2.15 ft. Therefore, the maximum collar spacing is (14) (2.15 ft) = 30.1 ft.

Details and installation instructions for corrugated metal collars are shown in figure I-28. For helical pipe collars, see figure I-29.[1/]

[1/] Pages 59-63 of the source publication cited above should be consulted for detailed design specifications.

CONTROL PRINCIPLE NO. 13

PROPERLY LOCATE AND SEAL SHAFTS AND BOREHOLES

Locate, fill, case, seal, or otherwise manage all boreholes, wells, shafts, and portals so as to prevent or control surface water and ground water pollution.

EXAMPLE

DOUBLE BULKHEAD MINE TUNNEL SEAL

Taken from: "Processes, Procedures, and Methods to Control Pollution from Mining Activities", p. 228-229. U. S. Environmental Protection Agenc EPA 430/9-73-011. October 1973.

The technique involves placement of two retaining bulkheads in a mine opening followed by placement of a seal in the [illegible] between the bulkheads. Bulkheads can be placed from a mine portal, if it is open and accessible, or through vertical boreholes from above. Grout or concrete is then placed between the bulkheads via pipes through the front bulkhead, if accessible, or from vertical boreholes.

Two types of double bulkhead mine seals have recently been successfully demonstrated. In inaccessible mine entryways a grouted seal has been used, and for accessible mines quick setting concrete seals have proven effective.

Grouted double bulkhead seals have been recently constructed at Moraine State Park, Pennsylvania, under the state's "Operation Scarlift" reclamation program. This method utilized dry, coarse aggregate for front and rear bulkheads placed through drill holes. The bulkheads were then grouted to form solid front and rear seals. Water was pumped out of the center cavity between the two bulkheads by newly placed drill holes. Concrete was poured into the space between the two bulkheads. These same mine seals have also been successfully installed without grouting the retaining bulkheads.

Use of double bulkhead seals for accessible mine entries has been attempted only a few times, primarily by the Halliburton Company under contract to the EPA. A quick-setting slurry consisting of water, cement, bentonite and sodium silicate was used to construct the two bulkheads. The void between the bulkheads was filled with a special light concrete composed of portland cement, fly ash, bentonite and water, pumped through a grout pipe. In another case, this void was filled with pneumatically pumped limestone aggregate, which was then grouted with light concrete.

These seals have been successfully demonstrated and appear capable of withstanding relatively large amounts of water pressure. The maximum pressure exerted has been limited to 10.7 meters (35 feet) of head. However, these seals should be capable of greater pressures as installation procedures improve.

Grout curtains are required for total effectiveness. Seal leakages generally occur through the bottom and around the sides of a seal. It is difficult to get a good seal at the mine roof because of slumping. The perimeter of a seal should be well grouted.

CONTROL PRINCIPLE NO. 14

CONTROL FUGITIVE DUST

Fugitive dust may result from any affected area or from any phase of any mineral industrial operation. Dust should be controlled when it contributes to chemical or physical water pollution. Particular attention should be given to control of wind blown fines containing toxic or radioactive contaminants.

EXAMPLE

HAUL ROAD DUST CONTROL

Taken from: "Erosion and Sediment Control - Surface Mining in the Eastern U. S." Volume 1: Planning, p. 58, and p. 9. U.S. Environmental Protection Agency. Technology Transfer Seminar Publication. October 1976.

"During dry periods, periodic watering of the roadway may be required to prevent the dust from entering the ditch. [Measures may also have to be taken to prevent windblown loss of mineral materials from trucks and railroad cars during transit.] Dust particles deposited in ditches, on the roadbed and [on other surfaces adjacent to the roadway] are washed readily into adjoining drainageways during rainfall events."

CONTROL PRINCIPLE NO. 15

MAINTAIN CONTROL MEASURES

Perform all maintenance necessary to insure the continued effectiveness of all control measures including drainage structures and treatment systems.

EXAMPLE

REMOVAL AND DISPOSAL OF SEDIMENT FROM A SEDIMENT BASIN

Taken from: "Erosion and Sediment Control - Surface Mining in the Eastern U S " Volume 1: Planning, p. 70-71. U.S Environmental Proection Agency Technology Transfer Seminar Publication. October 1976.

Sediment Removal

The most important maintenance problem associated with sediment containment basins is the removal of accumulated sediment. Research has shown that the highest sediment yields are usually observed during the first 6-month period after mining. Filling of sediments in the basin reduces its capacity to retain runoff long enough for sediment to be deposited before it is carried downstream. Many States have established criteria for sediment removal from the basin. A rule of thumb that can be used is to clean out a basin when it has reach 50 percent of its sediment storage capacity, or 6 months after the mining operation was started, whichever comes first.[1] In the design for storage capacity of a sediment basin, provisions should be made to accumulate enough sediment to permit the pond to function for a reasonable period between cleanings.

For small sediment traps used near the mining activity, cleaning is generally best accomplished by dragline and truck transport, since this equipment is readily available. Removed material can be stockpiled directly on the banks, and allowed to dewater before being hauled away, or it can be buried in the mine pit.

For large containment basins that cannot be cleaned by draglines operating from the banks, the cleaning becomes more difficult. In such cases, the services of professionals experienced in the handling and disposition of sediment should be retained.

[1] This example has been taken from information dealing with coal mining in the Eastern United States; this specific rule of thumb may therefore not be directly applicable to other mineral categories or to mining conducted in other parts of the country. Regulations promulgated under P.L. 95-87 (30 CFR 715.17(e)(5)) require sediment removal when accumulation reaches 80% of storage volume.

Sediment Disposal

Sediment disposal is an integral part of the sediment removal program from a containment basin. Indiscriminate piling or dumping of removed material is more likely to allow sediment to reenter the surface drainage system during successive storms, and thus become a pollutant again. The sediment removal operation must also consider the stable dispostion of the material removed from the basin. Where disposal of a small quantity of sediment is involved, it can be disposed of behind a protective berm or grass filter strip, or buried in the mine pit. For larger quantities of sediment, special provisions should be made either to bury it in an area designated for this purpose, or to stockpile, dewater, and vegetate it properly.

CONTROL PRINCIPLE NO 16

USE TEMPORARY STABILIZATION AND CONTROL WHEN NEEDED

Use temporary stabilization and control measures when transitory conditions are created during conduct of mine-related industrial operations, which present a significant water pollution hazard, including those created during periods of inactivity.

EXAMPLE

TEMPORARY STABILIZATION OF SEGREGATED TOPSOIL IN SURFACE MINING

Taken from: "Environmental Protection Performance Standards." Public Law 95-87. Surface Mining Control and Reclamation Act of 1977, Section 515(b)(5). August 3, 1977.

"General performance standards shall be applicable to all surface coal mining and reclamation operations and shall require the operation as a minimum to remove the topsoil from the land in a separate layer, replace it on the backfill area, or, if not utilized immediately, segregate it in a separate pile from other spoil and, when the topsoil is not replaced on a backfill area within a time short enough to avoid deterioration of the topsoil, maintain a successful cover by quick growing plant or other means thereafter so that the topsoil is preserved from wind and water erosion, remains free of any contamination by other acid or toxic material, and is in a useable condition for sustaining vegetation when restored during reclamation, except if topsoil is of insufficient quantity or of poor quality for sustaining vegetation, or if other strata can be shown to be more suitable for vegetation requirements, then the operation shall remove, segregate, and preserve in a like manner such other strata which is best able to support vegetation."

CONTROL PRINCIPLE NO. 17

PREVENT AND CONTROL POLLUTION AFTER CLOSE DOWN OR ABANDONMENT

Close down, remove or abandon all structural measures, facilities and areas affected by mine-related industrial operations upon completion of activity so as to prevent or control long term postoperational surface water and ground water pollution.

MINE HAUL ROAD STABILIZATION UPON ABANDONMENT

Taken from: "Abandonment of Haulageway." West Virginia Department of Natural Resources Surface Mining Reclamation Regulations, Chapter 20-6, Series VII, Section 5.16. 1971.

"Upon abandonment of a haulageway, the haulageway shall be seeded and every effort made to prevent erosion by means of culverts, water bars and other devices."

CHAPTER 5.0

ABANDONED SOURCE ABATEMENT

5.1 Introduction

EPA has published a report entitled "Criteria For Developing Pollution Abatement Programs For Inactive and Abandoned Mine Sites," (EPA-440/9-75-008, August 1975), which describes organizational, financial, and legal considerations involved in implementing a water pollution abatement program for abandoned sources. It also discusses technical approaches to collecting mine-related water quality data, conducting mine source inventories, and identifying control needs and priorities.

Abandoned mine-related sources include abandoned surface and underground mines for all mined mineral commodities, attendant waste and tailings piles, roads, storage areas and related primary processing areas, and in place pollutants accumulated in aquifers or deposited in earlier years in streambeds and lakebeds.

The most important aspect of WQM for abandoned mine-related sources will frequently be the program implementation requirements, rather than the technical engineering aspects. Legal, institutional, and financial arrangements hold the key to progress and success of abatement programs more often than engineering studies and water quality data.

Information defining the nature and extent of water quality and beneficial water use impacts, and technical options and costs of abatement controls, must be available in order to justify and to gain support for development of an abatement program with an adequate legal, institutional and financial foundation, and to provide an accurate estimate of the total cost of needed abatement efforts.

In those instances where pollution abatement programs for abandoned mines already exist, the adequacy of these programs should be objectively evaluated within the WQM program context. Plans for modifying existing program objectives, scope, scheduling and organization should be developed as needed to achieve water quality goals and to protect beneficial water uses.

Abatement programs and active regulatory control systems should be coordinated to clearly assign the responsibility for preventing and controlling continuing surface water and/or ground water pollution from future inactive and abandoned mines. Any further growth in adverse water quality and beneficial use impacts from abandoned sources should either be precluded entirely or be recognized and planned deliberately.

Most reclamation projects on abandoned mined lands have dealt with coal mine-related sources, but some States have also dealt with sand and gravel, clay, stone, phosphate, copper, gold, and other mineral subcategories. Expanding abatement programs to deal with abandoned sources from all mineral subcategories, including oil and gas wells, is consistent with the control mandate of the WQM program.

When implementation is to be undertaken by an organization other than the planning agency itself, the WQM agency should involve the implementation agency at the earliest possible date in its program development effort. This early involvement is particularly appropriate if the WQM agency is unfamiliar with the highly technical engineering aspects of the program. Abatement strategies and control alternatives proposed by an implementation agency participating directly with a WQM agency would have to be responsive to WQM program goals for pollution load reduction and beneficial water use protection and restoration.

5.2 Abatement Program Tasks

Definitions of current, new, inactive, abandoned, orphaned and pre-law mines and mineral extraction and processing operations sites will vary with applicable laws and institutional arrangements. Abandoned mines and supporting facilities generally are those that are no longer owned and/or intended for continuing mineral production by the mining industry. Inactive mines and supporting facilities are usually not currently producing but are expected to operate when mineral prices, extraction technology, or other mineral industrial conditions become favorable. Inactive operations owned by private citizens, governmental authorities, industries or Indian tribes probably will be treated quite differently because of legal considerations and abilities of the various groups to assume pollution control responsibilities. Abatement or control of pollution at inactive mines must be arranged at the State and local level among WQM agencies, mine source owners, affected citizens, and other responsible government agency officials.

Major steps involved in State and areawide abatement program development follow:

WQM Task - Define objectives for the abatement program.

Both short and long term objectives should be developed. Water quality improvement objectives normally will be integrated with other desirable goals related to aesthetics, economic development, land use, land productivity, public safety, terrestial ecology and correction of other adverse environmental impacts. Objectives should be consistent with and supportive of wildlife management plans and programs applicable to each jurisdiction.

WQM effort logically should emphasize direct abatement of water pollution. The task of ameliorating all adverse environmental impacts from abandoned mine-related sites is a much larger undertaking than controlling only the most serious water quality and beneficial use impacts. Abatement programs must be integrated with other objectives (aesthetics, etc.) in order to gain adequate public and political support; but, at a given level of effort, the greatest improvement in water quality will obviously be achieved through concentration on the objective of water pollution control.

As stated in Chapter 2.0, revised Water Quality Standards should adequately cover all significant pollutants from abandoned mine sites. Critical design flow conditions should reflect the conditions in receiving waters in which mine-related pollutants pose the most serious threat to water quality goals and beneficial water uses.

Technical information often may not be available for reliable quantitative estimation of nonpoint source pollution load contributions, modeling of instream effects, and determination of beneficial use impacts. Abatement efforts nevertheless should be launched on judgments of pollution severity and abatement measure cost effectiveness. Abatement measures should be implemented for abandoned mine-related sources whose uncontrolled pollutant contributions interfere with achievement of water quality goals and beneficial water uses.

WQM Task - Examine existing legal and institutional arrangements for abandoned mine pollution abatement.

New institutional, legal, and financial arrangements should be proposed where existing abatement programs are not adequate to achieve WQM program goals.

WQM Task - Select one or more implementation agencies to participate with the WQM agency in developing and implementing an abandoned source abatement program.

Legal constraints related to land ownership and mineral rights patterns, as well as other social and economic distinctions,may dictate separate institutional arrangements and abatement program efforts for dealing with pollution abatement on Federal property, State property, local government holdings, industrial lands, private ownerships and Indian lands.

When a WQM agency selects another agency or agencies to participate in an effort to develop an abatement program, wide latitude exists for making joint funding and work program arrangements. Ultimate responsibility and control of the WQM aspects of the program development effort should rest with the WQM agency.

It may be best for the WQM agency to handle some of the remaining abatement program tasks, while other tasks may be accomplished through an implementation agency that has more technical expertise in abandoned mine pollution abatement.

The program tasks that follow may be accomplished either by WQM agencies, by implementation agencies, or by qualified contractors under their separate or joint direction:

WQM Task - Investigate legal problems and alternative solutions.

In investigating legal issues. the responsibility for abatement funding in each class of inactive or abandoned mined land must be determined. Decisions must be made as to whether private landowners, the mining industry, taxpayers, or which one of the various levels of government will bear the cost of abatement. One of the legal issues requiring resolution may include conflicts between surface owners and mineral rights holders.

Landowners and industries should be encouraged and offered incentives to become involved in voluntary and cooperative abatement projects. Industries should be encouraged to reaffect previously mined lands as a part of the abatement program. Existing laws at the local, regional, State and Federal levels requiring pollution control by landowners, former mine operators, and present mine operators should be used to the limits of equity before new legislation is proposed to abate pollution from abandoned mines. Legal and institutional issues involved in mine-related WQM are discussed in "Legal and Institutional Approaches to Water Quality Management Planning and Implementation," EPA Contract Report No. 68-01-3564, March 1977.

WQM Task - Identify funding sources and arrange funding mechanisms for mine-related pollution abatement.

Funds available for various types of abatement projects at local, State and Federal levels should be determined. Potential funding sources for planning tasks and data acquisition should be sought as well as for actual mine-related source abatement and construction work.

WQM Task - Identify and describe principles, processes, methods, procedures, measures, and techniques for abatement of pollution from abandoned mine-related sources, which interfere with achievement of water quality goals and beneficial water uses.

The term Best Management Practices has a different meaning and carries with it different connotations, when applied to abandoned sources than when applied to current sources. Procedural methods and preventive measures could normally not be applied to an abandoned source; by definition no mine-related activities or operations are being conducted at abandoned source locations wherein preventive or procedural BMP's could be applied. Some mitigating control practices which are applied to current sources might be applied to abandoned sources, but only with modifications reflecting all of the physical, institutional, legal and financial distinctions.

Table 5.1 illustrates the range of mine drainage pollution abatement and control techniques identified in a study of acid mine drainage performed under the auspices of the Appalachian Regional Commission (ARC) in 1969.

Abatement technique comparisons and study efforts similar to this one are required for each type of abandoned mine-related

TABLE 5.1

MINE DRAINAGE POLLUTION ABATEMENT AND CONTROL TECHNIQUES

Type[1]		Abatement Category[2]	Description	Application Characteristics		
				Mine Type[3]		Mine Drainage Class[4]
				Surface	Underground	
Surface Land Reclamation	**	1	The grading of earth, the construction of water ditches and revegetation of ground disturbed by excavation of the surface.	A I	– –	1 2 3 4
Mine Entry Sealing	**	1 and 4	The placement of barriers in openings from underground mines exposed to the surface to constrain the movement of air or water.	– –	– I	1 2 3 4
Drainage Diversion	**	1	The channeling of surface waters or mine waters to control volume, direction and contact time.	A I	A I	1 2 3 4
Impoundment	**	1	The physical restriction of waters within an isolated area of an underground or surface mine.	– I	– I	1 2 3 4
Refuse Pile Reclamation	**	1	The burial or covering and revegetation of the discarded waste rock from mining.	A I	A I	1 2 3 4
Underground Grouting	**	1 and 4	The placement of a sealant on the surface or into the subsurface to constrain the movement of air and water in an underground mine, e.g., the pouring of concrete which would seal after reaching subsurface.	– –	– I	1 2 3 4
Revegetation	**	1	The planting of grasses, legumes or trees upon the surface of areas disturbed or altered by excavation or dumping during mining.	A I	– –	1 2 3 4
Inert Gas Blanket		1	The placement and retention within an underground mine of a gas that is not reactive in the acid mine drainage forming process.	– –	– I	1 2 3 4
Microbiologic Iron and Sulfate Removal		1	The use of living organisms to actively reduce acid mine drainage contaminants.	– I	A I	1 2 3 4
Sterilization		1	The use of toxic materials to destroy or retard living organisms active in the acid mine drainage forming process.	– –	A I	1 2 3 4
Microbiological Control		1	The use of living organisms against each other to retard the action of those which are active in the acid mine drainage forming process.	– –	– I	1 2 3 4
Internal Sealing		1 and 4	The isolation or constraint of underground mine waters by the placement of barriers well within the depths of underground mines.	– –	A –	1 2 3 4
Resource Removal		1	The extraction of all coal, and the burying and sealing of toxic producing strata.	A I	– –	1 2 3 4
Neutralization	**	2	The process of chemically counteracting the polluting effects of acid mine drainage.	A I	A I	1 2
Flash Distillation		2	The rapid evaporation of acid mine drainage and the reliquefication of the remaining fluid, free of residual contaminants.	A I	A I	3

TABLE 5.1 (Continued)

MINE DRAINAGE POLLUTION ABATEMENT AND CONTROL TECHNIQUES

Type[1]		Abatement Category[2]	Description	Application Characteristics: Mine Type[3]: Surface	Application Characteristics: Mine Type[3]: Underground	Application Characteristics: Mine Drainage Class[4]
Reverse Osmosis	**	2	The passage through a selective membrane of the liquid portion of acid mine drainage thereby freeing it from a major portion of the residual contaminants.	A I	A I	1 3
Ion Exchange		2	The passage of acid mine drainage among reactive particles that selectively retain residual contaminants while the remaining liquid passes through.	A I	A I	3
Desulphating		2	The use of living organisms that thrive on metabolic processes that destroy sulfate, which is a major residual contaminant of mine drainage.	A I	A I	3
Sulfide Iron Removal		2	The precipitation of iron from acid mine drainage with the addition of selectively reactive sulfide compounds.	A I	A I	1 2 4
Electrodialysis		2	The passage of acid mine drainage through an electrically charged selective membrane allowing the passage of liquid thus freeing it from residual contaminants with the appropriate electrical resistance to passage.	A I	A I	3
Permanganate Iron Removal		2	The precipitation of iron from acid mine drainage with the addition of an agent that oxidizes the iron.	A I	A I	1 2 4
Regulated Pumping	**	1 and 3	The discharge of acid mine drainage at volumes, rates, times and locations so that the contaminating effects will be minimized.	A I	A I	1 2 3 4
Stream Flow Regulation	**	3	The containment and release of stream waters at volumes, rates, times and locations so that the contaminating effect will be minimized.	A I	A I	1 2 3 4
Deep Well Injection	**	4	The placement of acid mine drainage or its altered product into the subsurface through a vertical drilled hole.	A I	A I	1 2 3 4

[1] Practical Range of Abatement Techniques is designated with **.

[2] 1. At-source control, by prevention or reduction of the rate of pollution formation.
2. The treatment of polluted waters.
3. The planned dispersion or dilution of pollutants.
4. The permanent containment or isolation of polluted waters.

[3] A = Active; mines and areas in use for mining.
I = Inactive; closed or abandoned mines or portions of active mines not in use.

[4] Mine Drainage Class: Numbers refer to classification in Table 2.

related source or source subcategory contributing to surface water and ground water pollution.

Control techniques should be classified according to the specific pollutants which each has been developed to prevent or reduce. Techniques also must be further classified by their proven effectiveness and applicability for practical field use. These classifications may include:

1. Techniques whose effectiveness and applicability are well demonstrated;
2. Techniques whose effectiveness and applicability are supported by limited field demonstration;
3. Techniques currently being demonstrated; and
4. Techniques currently under conceptual development.

The 1969 ARC coal mine drainage study stated that "There are some 24 techniques, which can be used singly or in combination, for the abatement and control of acid coal mine drainage. Of these, fewer than one-half have been either sufficiently tested or applied to allow an appraisal of their practicality for use in defined situations."

Mine-related source conditions under which each control technique is utilized most appropriately as well as the range of conditions across which the technique remains effective should be defined.

In those cases where effective at-source control techniques for a specific source subcategory are unknown, control measures can sometimes be borrowed from other similar situations found in other segments of the minerals industry.

Alternatively, the hydrological, physical and chemical elements of the problem can be studied and remedies proposed, or investigative research efforts launched to study the problem and to develop and test solutions. Direct treatment of abandoned source discharges or treatment of affected streams should be evaluated as one control alternative.

WQM Task - Determine the relative costs of available pollution abatement techniques.

Variation in application costs across the range of site conditions under which each technique is applied should be considered, as well as any continuing operating and maintenance costs, such as those associated with direct treatment.

WQM Task - Determine the effectiveness of abatement techniques used singly or in combination for control of abandoned mine-related pollutant contributions.

If quantitative field data are lacking, percent load reductions should be estimated for various techniques, combinations of techniques, and mine-related source conditions. The number of techniques which can be applied to abate a specific mine-related source is usually very limited; the choice of alternatives is often confined to only one or two options. Greater flexibility and a wider range of alternatives exists in scheduling and establishing priorities for abatement than for technique selection. Source conditions frequently dictate use of a specific technique or combination of measures to achieve a significant reduction in the pollutant load.

WQM Task - Evaluate the cost effectiveness of alternative abatement techniques and of abatement of sources within different watersheds and mine-related source subcategories.

Examination of cost effectiveness permits comparisons of both alternative techniques and abatement program actions. Since so few abatement alternatives exist at each specific mine site, cost effectiveness is likely to be more important for selecting among abatement projects for different individual mine-related sources, or for dealing with different source subcategories on a watershed basis than for choosing among alternative abatement techniques for any one source.

Benefits derived from restoration of polluted waters to a condition permitting higher uses, including propagation of fish, shellfish, and wildlife, should be estimated.

WQM Task - Collect and analyze socio-economic information for establishing watershed and mine-related source pollution abatement priorities.

Factors taken into consideration might include population, economic need, development demand, aesthetics, and land values and uses.

WQM Task - Determine priorities for watershed and mine-related source pollution abatement.

Priorities should be established primarily on the basis of how much of an improvement in beneficial surface water and ground water uses can be predicted to result from taking abatement action, the cost of such action, and the importance attached to achieving such uses. Schedules for pollution abatement in each subprogram area should strongly reflect abatement priorities.

Other factors which must be considered include the future possibility of reprocessing mine wastes and tailings, the remining of previously affected sites, and the presence of mine-related sources for which abatement techniques currently are unknown or lack sufficient testing. Abatement efforts can be directly tied to water quality improvement through planning conducted on a watershed or ground water hydrologic unit basis. This insures that the combined influence of all mine-related sources, including the effectiveness of proposed abatement measures, will be taken into account in predicting improvements. The effect of current mines, new mines, and future inactive mines on water quality should also be considered. New source WQM efforts are discussed in Chapter 6.0. The physical and biological recovery potential of severely polluted streams and degraded ground waters will influence the advisability of taking abatement actions.

Separate abatement subprograms may be established for Federal lands, State lands, Indian lands, lands to be purchased by the State and reclaimed, industry abatement programs, industry/State voluntary cooperative efforts, private citizen cooperative efforts with State and Federal agencies, and property acquisition and abatement efforts by local government. Because of differences in legal responsibilities of landowners, mineral claims holders, current and former mine operators, etc., distinctions are likely between pre-law mine operations and operations conducted under previous State, local, or Federal control programs.

Responsibility should be assigned for control of pollution from current and from new mine-related sources after abandonment. Mine-related source closure and mine shutdown procedures may not adequately prevent these sources from continuing to cause pollution. Failure to assign responsibility for postoperations pollution control may result in defacto assumption of liability by government.

WQM Task - Develop alternative subplans for control of water pollution from abandoned mine-related sources.

Alternative pollution abatement subplans for abandoned mines should include (1) an estimate of the best reduction levels achievable from all sources; and (2) the most practicable program that the WQM agency can accomplish. The most practicable subplan should reflect the WQM agency's current appreciation for technical, legal, financial, and institutional constraints.

In those instances where wide disparity exists between the best achievable and the currently practicable subplans, at least one other alternative should be developed. This subplan should define an abatement program that would permit substantial progress in restoration of beneficial water uses through pollutant load reduction, and the scope of legal, institutional and financial arrangements which would be necessary to carry it out (recognizing that such arrangements may not be easily made).

The practicable abatement subplan must attain at least the same level of continuing achievement as any existing abatement program(s), and, in addition, make provision for positive but still realistic program expansions and improvements.

A limited environmental assessment should be made of each proposed subplan. The subplan's contribution to improving water quality and beneficial water uses, as well as the economic impacts on industry, private citizens and various levels of government should be emphasized.

Work performance schedules should be set for a 20 year period in 5 year increments with corresponding estimates of surface water and ground water quality improvement tied to scheduled abatement program accomplishments. Predictions of water quality improvement from abatement of existing abandoned mine-related sources must be integrated with water quality data having to do with current sources, new sources, and future abandoned sources.

WQM Task - Compare abandoned mine-related loads and/or impacts on beneficial water uses with other nonpoint source pollutant load contributions and impacts, and with the gross allotments for nonpoint source pollutants on water quality limited segments where allotments have been prepared.

WQM Task - Select a source abatement subplan(s) for abandoned mines.

> EPA states in its WQM planning guidance that "No rigorous analytical method exists which will readily identify the best plan for the area... while some of the factors... can be quantified, others can only be qualitatively assessed based upon professional judgment, and the views of the public."

The implications of the selected subplan for, and its interrelationships with, current mining, new mining and other nonpoint and point source control subplans must be taken into account as a part of the overall WQM plan selection process. Inter-state, inter-area and other inter-jurisdictional coordination should also be accomplished.

The source control subplan that is chosen should permit attainment of water quality goals and restoration and protection of beneficial water uses. Specific geographic areas should be identified where goals are unattainable. Established procedures must be followed to seek exception to designation of national goal water uses (fishable, swimmable waters) in any water quality limited segment because of abandoned mine-related pollutant contributions.

Exceptions to national goal use designations might be sought in situations where direct treatment of abandoned source discharges or affected streams is shown not to be practicable, and where: (1) abatement measures or techniques for reducing current levels of abandoned mine-related pollution have not been developed; and (2) projected levels of water quality improvement, following application of known abatement measures and techniques, are predicted to be inadequate to achieve national goal water uses and restore beneficial uses.

In-stream treatment has been used, but only rarely by some States to correct and abate otherwise insoluable pollution impacts; continuing operating and maintenance costs using direct treatment can be burdensome. The continued validity of each case of exception to national goal water use designation because of abandoned mine pollution should be reviewed every three years as a part of the Water Quality Standards review process.

WQM Task - Perform an environmental assessment of the selected abandoned source abatement subplan.

The environmental assessment for the selected subplan should be prepared in greater detail than previously accomplished for each alternative subplan and include a wider range of social, economic and broader environmental impacts. EPA's guidance document "Environmental Assessment of Water Quality Management Plans," October 1976, contains further discussion of this topic.

5.3 Abatement Program Implementation

In implementing abatement programs and in actually accomplishing abatement projects, a series of tasks should be repeated. The task sequence is described below:

WQM Task - Conduct watershed feasibility studies for source abatement in highest priority areas.

The watershed feasibility study involves a more intensive survey within a priority watershed. The purpose is to develop a specific abatement plan for a defined surface water drainage area or ground water recharge zone.

Recommendation of a specific abatement plan is the final step prior to initiating the engineering design projects for abatement of particular pollution sources. The watershed feasibility study may be considered either as the last and most detailed stage of the WQM process done by or through the WQM agency, or as the first stage of the actual implementation process done by the management agency.

The feasibility study involves most of the major steps found in the identification and assessment process described in Chapter 2.0 and the selection of controls process described in Chapter 3.0, but at a level of specific detail necessary to define the scope, purpose and objectives of actual engineering design projects for abatement of individual sources.

WQM Task - Perform engineering design for abatement projects and carry out the required field work, reclamation, and construction efforts.

WQM Task - Monitor post-abatement water quality and biological recovery to determine and assess water quality and beneficial use improvements achieved through abatement project work.

Post-abatement monitoring information is needed to document the effectiveness of applied abatement measures. This information may influence estimates of cost effectiveness and the choice of pollution control techniques for other sources. To properly gauge the long-term effects, chemical and biological monitoring may be conducted for five or more years following application of abatement measures. Reworking of abandoned tailings and other mine-related wastes may sometimes cause temporary increases in pollution levels because of exposure of new material to oxidation and weathering processes. Ground water contamination problems may also be slow to improve following accomplishment of abatement efforts and may require relatively longer monitoring periods for proper documentation of improvements.

CHAPTER 6.0

NEW SOURCE POLLUTION CONTROL PLANNING

6.1 New Source WQM Program Requirements

WQM planning for new mine-related water pollution sources is required of WQM agencies under Part 131 of EPA's Rules and Regulations, "Preparation of Water Quality Management Plans."

The WQM planning requirements cited in Subpart 131.10(g) of the regulations which relate most directly to future-oriented planning are:

1. Water quality assessment and segment classification;
2. Inventories and projections;
3. Nonpoint source assessment;
4. Industrial waste treatment system needs; and
5. Nonpoint source control needs.

Pollution control planning efforts conducted by State and areawide WQM agencies which are related to new sources of water pollution from new mine-related industrial operations will fall into one of two categories: (1) routine new source planning; or (2) major new development planning.

Consideration of routine new point and nonpoint mine-related sources will be a standard component of all WQM programs. Routine new source WQM planning involves projecting the impacts of ongoing, mine-related pollution sources on water quality and beneficial water uses for the 20 year planning period. This projection is accomplished largely by extrapolating current trends, and the operation of existing control systems or of proposed control system alternatives into future years.

WQM planning for major new expansions, developments or other initiatives of mine-related industries, however, will only be appropriate within those relatively few jurisdictions that anticipate large-scale increases or changes in the character of current mine-related industries. The need to conduct an effective planning effort will be most urgent and demanding in those areas where major new initiatives are expected during the first five-year planning period (1979-1983). The need for such new source planning will be less critical (and initially of somewhat lower priority) in those cases where significant new developments are not expected before 1983. Routine new source planning still will have to be conducted in most areas where major new development planning is needed. For example, the need to examine future impacts from sand and gravel, stone quarrying and other common variety operations will still exist in areas anticipating major new coal, lignite, oil, gas, oil shale, geothermal, phosphate or other mineral industrial developments.

The most important distinction between the routine and the major development planning orientations is the different basis each one must use for water quality problem recognition and control strategy development. In routine planning, the biggest part of problem recognition and control design is predicated on the known impacts of current and recently completed mine-related operations on water quality and the documented effectiveness of existing control systems in preventing and controlling these pollutant contributions. In new development planning, on the other hand, problems which presently may not exist will often have to be anticipated, and appropriate control systems developed on the basis of potential impacts from projected mine-related operations. Planning for major new mine-related industrial developments also will often involve projecting secondary associated growth impacts that may result in substantial increases in municipal and other industrial point source and nonpoint source loads.

Continuing water quality management and WQM planning processes for new mine-related sources are discussed in Chapter 7.0.

6.2 Pollution Control Planning for Routine New Sources

WQM planning for new mine-related sources will be a part of virtually all WQM programs. Routine new source planning should be accomplished simultaneously using a similar sequence of tasks with current and abandoned mine-related WQM efforts (see Chapters 2.0, 3.0 and 5.0).

The initial definition of control/management system needs in Chapter 1.0, Section 1.3, involved an examination of past, present and future mine-related industrial operations within the planning area. In the majority of instances, distinctions between requirements for routine new source planning (described in this Section) and for major new development planning (described in Section 6.3) can be made on the basis of information readily available to WQM advisory committees, from sources such as: (1) mining industry representatives; (2) State Geological Survey; (3) State Bureau of Mines; (4) U.S.D.I. Geological Survey; and (5) U.S.D.I. Bureau of Mines.

Each of the major identification and assessment tasks presented in Chapter 2.0 and the majority of the current source control tasks presented in Chapter 3.0 should be performed. Routine new source WQM tasks include:

WQM Task - Subcategorize mine-related sources.

All new mine-related industrial operations which are expected to be active within the 20 year planning period, but especially within the first 5 years of that period, should be recognized as potential pollution source subcategories for which advance control planning should be initiated.

WQM Task - Review Water Quality Standards.

Water Quality Standards should include as criteria all those specific pollutant parameters associated with new mine-related point and nonpoint source subcategories.

Integration of biological indices and criteria into revised Water Quality Standards may help to gauge impacts of nonpoint source pollutants on aquatic life.

State governments should also review their anti-degradation policies, particularly in relation to the gradual degradation of existing high quality and National resource waters and sole source aquifers. Over a period of years, degradation may occur as a result of some forms of extensive mining and other mineral industrial activities. Such degradation can occur even when all mine-related operations are conducted under an established permit control system. Water pollution, which occurs in spite of operation of a control system, most often can be traced to a lack of rigorous enforcement combined with the technical limitations of the best available preventive measures and control practices, with emphasis on the former.

WQM Task - Projection of future mine-related sources.

As a part of the inventory and projection effort required to comply with Part 131.11(c)(1) of EPA's published Rules and Regulations, the extent of new mine-related sources should be projected through the 20 year WQM planning period. At a minimum, the anticipated number of new point and nonpoint sources of each type and/or the extent of affected area should be estimated. The number of previously mined areas that could be reaffected by the mining industry is an important factor in predicting future water quality impacts, as is the number and extent of future inactive and abandoned sites. The implications of predicted growth in other municipal and industrial categories which influence demand for mineral commodities may help in estimating future levels of activity in some mine-related industrial subcategories. For example, once estimates of future growth in road, housing and other construction activities are estimated, the quantities of locally mined and processed sand and gravel, and crushed stone from rock quarries needed for these projects also can be estimated.

Numerical estimates of new sources within each surface watershed or ground water recharge zone should be prepared as a part of routine projection efforts. If mining is not central to the WQM program no need exists to investigate detailed location of recoverable mineral deposits and specific development sites. However, economic geology information showing the general drainage areas where new mineral industrial activity will take place should be used. Also, any available information concerning relative pollution hazards associated with different future sources should be integrated into the projection. This information may include geochemical, hydrological or topographic data from areas of anticipated future mine-related activity. Exhaustive studies of economically recoverable mineral deposits, mineral rights and surface rights ownership are more appropriate for WQM planning for major new developments than for modest routine planning efforts.

Mine-related activity projections, even when highly generalized, can be useful for identifying potential control needs. For example, assume that a given jurisdiction includes 100 active and 200 inactive or abandoned mineral industrial operations sites. Also, assume that: (1) the average site remains active for 5 years; (2) 20 new sites open each year (assuming ready availability of new mineral development sites); and (3) 20 currently operating sites are abandoned or become inactive each year. Under these conditions, at the end of a 20 year planning period, 100 sites would still be actively operating, while the anticipated number of inactive or abandoned operations sites would have grown from 100 to 500.

The level of detail used in new mine-related source projection will depend on how sophisticated an analysis is planned for assessing water qualty impacts and evaluating control needs.

WQM Task - Perform water quality and nonpoint source assessment and segment classification.

Part 131.11(b)(1) of EPA's Rules and Regulations states that one of the elements which "shall be included in each water quality management plan . . . [is] an assessment of existing and potential water quality problems within the approved planning area or designated areawide planning area, including the types and degree of problems and the sources of pollutants (both point and nonpoint sources) contributing to the problem." Mine-related industrial new source projections should be used as the basis for predicting water quality and beneficial water use impacts. One of the first tasks involves recognizing specific water pollutants and hydrologic impacts likely to be associated with each projected type of mine-related industrial operation. The amount of emphasis on quantification of pollutant loads likely will be relatively low, particularly from mine-related nonpoint sources. Recognition of the need for quantitative load estimates will be tempered by both the reliability of available prediction methods and the amount of pre-operations planning effort which is likely to be accomplished for each new source prior to its activation under existing or proposed regulatory controls. In addition to State and local permit requirements, environmental impact statements or assessments may be prepared by EPA for some new NPDES permits in compliance with the requirements of NEPA.

In classifying drainage segments as either "water quality limited" or as "effluent limited", WQM agencies must recognize future pollutant loads or load potential, as well as existing loads. Part 131.11(b)(2)(ii) of EPA's Rules and Regulations states that, "Water quality problems generally shall be described in terms of existing or potential violations of water quality standards." In addition to violations of standards, potential degradation is also an important concern. Part 130.17(e)(2) of EPA's Rules and Regulations states that "Existing high quality waters which exceed those levels necessary to support propagation of fish, shellfish and wildlife and recreation in and on the water shall be maintained and protected unless the State chooses . . . to allow lower water quality [but still without violating Water Quality Standards] . . . . Additionally, no degradation shall be allowed in high quality waters which constitute an outstanding National resource, such as waters of National and State parks and wildlife refuges and water of exceptional recreational and ecological significance."

Effluent guidelines limitations for new mine-related industrial point sources in all mineral subcategories (including in some cases "no discharge" requirements) will be useful for estimating future point source load contributions. However, volumes of flows will have to be estimated. Probably the easiest method for quantitative projection of future loads is to use the same method as was used for estimating existing loads from current and abandoned sources. The status of predictive models for estimating loadings, transport and in-stream water quality and beneficial use impacts of mine-related pollutants was discussed briefly in Chapter 2.0, Section 2.2.6.

Modeling is unlikely to generate absolutely accurate estimates, but such analyses may at least reflect the potential magnitude of future problems and associated control needs. The most realistic projections of potential loads can be prepared where future sources are similar to existing sources, and where models have been appropriately calibrated and verified.

Gross quantitative estimates of future potential pollution loads or maximum in-stream concentrations may be developed from mineral production forecasts or projections. This approach would require than an empirical relationship be established between production of a given mineral and attendant potential pollution contributions and impacts.

Impacts of unregulated subcategories, recognized to be contributing sources of pollution, should be estimated. The cumulative future potential impact of small operations, which presently may be excluded from control may be in this category. The cumulative impact of an increasingly large number of unregulated sites, which become inactive or abandoned over the 20 year planning period, should be considered, as well as any growth in the number or the extent of active operations across the same period.

If mine-related operations and closedown procedures could be well planned and sufficiently controlled, long-term mine-related pollutant contributions could approach zero. The best available preventive measures and control practices (BMP's) are seldom so well chosen and conscientiously applied, but even when this does occur, some level of long-term pollutant contribution to surface water and/or ground water may still take place. Because of technical limitations, such lingering problems may remain even when BMP's are applied. For planning and impact projection purposes, if long-term, mine-related pollution contributions are predicted to be nominal (i.e., so extremely low that even their cumulative effects are judged insignificant), and if potential pollutant contributions from post-mining land uses are expected to be large by comparison, further consideration of such inactive or abandoned mine-related sites as contributing mine-related pollution sources may be ended, and their contributions neglected.

A former surface mine supporting native or introduced tree growth should not automatically be assumed to be equivalent to a forest in the hydrologic sense. The water quality and beneficial water use implications of proposed post-mining land uses must be dealt with by appropriate administrative linkages to other water pollution control programs for sources in other categories, such as agriculture, silviculture, urban drainage, etc.

The probable future impact of mine-related activities on water quality is estimated by projecting existing trends and conditions across the 20 year planning period A separate projection should be attempted for improvements in proposed control systems that would reduce pollution contributions from presently existing sources, near-term future sources, and more distant future sources.

Planned reductions in pollutant contributions from inactive and/or abandoned mine-related sources from operation of abatement programs should be factored into the 20 year water quality projection.

The projection of future impacts from mine-related activities should serve as the basis for recognizing potential water pollution contributions that would require prevention and control. These potential contributing sources are those not likely to be adequately controlled, by the existing system, or by implementation and continued operation of an earlier proposed control strategy for current sources.

Those components of the existing, or of the proposed, control systems projected to be inadequate or ineffective in dealing with future pollution sources should be specifically identified and strategies for more effective control and management developed.

WQM Task - Develop alternative control and management system strategies. Technical aspects of alternative strategies for future sources should be based on previously identified control methods, measures, procedures, practices and techniques which are applicable to each mine-related source subcategory (see Chapter 3.0, Section 3.3). Some experimental control methods which were classified earlier as not yet ready for practical application, may be ready for implementation at some point during the 20 year planning period. Representatives of mine-related industries should provide ideas concerning practical control methods and measures to deal with anticipated future problems. The legal prerequisites and managerial aspects and economic implications of alternative control strategies should also be examined. Some alternatives might involve description of a phased series of actions scheduled to take place at specified time intervals over the 20 year span.

WQM Task - Estimate the effectiveness of alternative control strategies. The probable effectiveness and limitations of alternative control strategies should be estimated to aid in comparing and selecting subplans. As described earlier in Chapter 3.0, Section 3.3, land use requirements for new mine-related sources would be included in a "fully effective" control system when permitted mine operations alternatives, including a system applying BMP's, are projected to fail to meet water quality goals or to adequately protect beneficial water uses.

WQM Task - Select a new source control subplan.

The selected control subplan should be the most effective in preventing and controlling all forms of mine-related water pollution and adverse beneficial water use impacts which can be implemented at either the State or the area-wide level.

WQM Task - Perform an environmental assessment of the chosen new mine-related water pollution control subplan.

In addition to description of the water quality, beneficial use, and economic implications of implementing a new source control subplan, broader social and other environmental consequences of carrying out the selected subplan should be assessed

The selected new source control subplan should be integrated with chosen current and abandoned mine controls and be made a part of the complete State or areawide WQM plan.

6.3 Pollution Control Planning for Major New Mine-related Industrial Developments

Pollution control plans for major new mine-related industrial developments projected during the 20 year period, will follow a task sequence similar to that of routine planning, but with a number of important distinctions.

Development planning must consider associated growth in other sectors (in population, housing, industry, utilities, etc.) which is likely to accompany large-scale, mine-related industrial expansion. This type of planning also will require greater depth and detail in projection of mine-related industrial activities, and may have to deal more thorougnly with antidegradation issues than will routine new source planning. In an area anticipating major new mine-related industrial development, it is also probable that the impacts of future water demands (quantity) and hydrologic changes on water quality and beneficial uses may require examination.

Only three of the nine routine new source planning tasks (see Section 6.2) may differ markedly when applied to new development planning. (These tasks are identified with an asterisk in the following list.)

*WQM Task - Identify new source subcategories.

All potential point and nonpoint pollution source subcategories associated with major new mine-related developments should be recognized. Potential sources include those which are directly mine-related, and those stemming from associated growth and development.

Directly mine-related source subcategories would include all contributing sources associated with mineral exploration activities, mine development, mineral extraction, mineral transport, mineral processing, mineral storage, and mineral waste disposal. Sources stemming from associated growth and development impacts would include pollutant contributions from mineral using industries, utilities, and expanding industrial and municipal sources linked to growth in population, residential and commercial development, and transportation systems.

WQM Task - Review Water Quality Standards.

Water Quality Standards should include criteria for all those specific pollutant parameters associated with new source subcategories. Social change and population growth resulting from major new mine-related industrial development may also bring about changes in beneficial surface water and ground water uses that would influence Water Quality Standards and goals.

*WQM Task - Project new sources.

Potential sources include both those which are directly mine-related and those which stem from associated growth and development.

Part 131.11(c)(3) of the U.S. EPA's Rules and Regulations dealing with preparation of WQM plans states that, one of the elements which shall be included in each WQM plan is "... demographic and economic growth projections for at least a 20 year planning period, disaggregated to the level of detail necessary to identify potential water quality problems." Within some major new mine-related development areas, the potential water quality impacts from associated growth and development may be more substantial than the potential water quality impacts from mine-related industrial operations per se.

Past environmental impact statements and assessment efforts are probably the best as well as the most readily available examples of mine-related water quality impact projection.

Some studies in this category are:

1. "Environmental Statement for the Proposed Prototype Oil Shale Leasing Program." U.S. Department of Interior, 1972.
2. "Environmental Impact Statement for the Proposed Federal Coal Leasing Program." U.S Department of Interior, 1974.
3. "Environmental Impact Statement for the Development of Phosphate Resources in Southeastern Idaho." U.S. Department of Interior, Geological Survey, and U.S. Department of Agriculture, Forest Service, 1976.
4. "An Environmental Assessment of Impacts of Coal Development on the Water Resources of the Yampa River Basin, Colorado and Wyoming." U.S. Department of Interior, Geological Survey, 1976.

These and other similar studies provide insight into the various approaches and methods which may be used to project future sources and, subsequently, to assess potential impacts on water quality.

Standard sources of information for use in projection of future mine-related expansion include the mining industry, the State Geologic Survey, the U.S. Geological Survey, and the U.S. Bureau of Mines.

Mapping and interactive manipulation of mapped or geo-coded information of different themes will frequently be an important part of new source projection efforts.

Every WQM effort will involve gathering of descriptive land resource information as part of the natural and cultural data base. Some data base elements will relate directly to mining, others will describe the various natural systems wherein mine-related activities take place. For example, the southeastern Idaho EIS investigation completed in 1976 included geologic maps and maps showing active federal phosphate lease boundaries, and information about applications for prospecting permits, competitive leases and preference-right leases. As a starting point in any mine-related activity projection, essential information includes a description of the characteristics and extent of commercially valuable, recoverable mineral deposits found within the boundaries of the planning jurisdiction and data pertaining to any limitations or conditions which might influence the probability of future mineral development. Economic geology information such as mineral formation and strata outcrop maps may be useful to show the extent of commercially valuable deposits, while land and mineral rights ownership data and overburden depth information may be useful to define some of the conditions and limitations to future development.

*WQM Task - Perform a future water quality assessment and segment classification.

The purpose of carrying out a water quality analysis effort is to identify the location of potential water pollution sources and the seriousness and extent of potential threats to achievement of water quality goals and protection of beneficial water uses.

The "relative" versus the "quantitative" approaches to water quality assessment were discussed in Chapter 2.0, Section 2.2.6, as these approaches relate to estimation of pollution loads from existing current and abandoned mine-related sources.

Description of potential pollution hazards in relative terms (i.e. this area is more hazardous than that area, etc.) is aided by examining probable interactions of anticipated mine-related activities with existing land resources and climatic regimes. To support this method of assessing relative pollution hazards, the southeastern Idaho EIS study (previously mentioned) used rainfall data, existing water quality information, wildlife habitat maps and landtype association maps, in combination with geologic and mine-related activity maps.

Quantitative estimates of future mine-related water pollution loads and their in-stream effects and beneficial use impacts are highly desirable, but as was mentioned earlier in Chapter 2.0, Section 2.2.6, reliable methods for quantitative impact prediction are not very well developed. EPA's "Areawide Assessment Procedures Manual", EPA-600-76-014, describes currently available alternatives for pollutant load modeling as including empirical methods, deterministic methods, stochastic methods, and simulation methods. Empirical loading methods, such as the Universal Soil Loss Equation, the Modified Musgrave Equation, and various loading functions, represent the most easily applied methods. As stated in Chapter 4 of the "Areawide Assessment Procedures Manual", use of empirical methods for solving pollutant loading problems "... outside the range of the original data base is risky and should be done only with full recognition of the possible errors." The manual further points out that application of any of the alternative methods for estimation of pollutant loads ideally requires local calibration and testing or verification, and the opportunities for performing meaningful calibration before calculating future potential pollutant load estimates obviously will be limited. Quantitative assessment is not complete until the loading model outputs have been input to suitable pollutant transport and water quality and beneficial water use impact models. Water quality impact models which deliver in-stream concentrations must include procedures to deal with in-stream water pollutant reactions and transformations as well as simply to accept loadings data from loadings and transport models.

The impacts of increased consumptive water uses on water quality may be important in assessing major mine-related industrial expansion impacts, particularly in arid or semi-arid climatic zones. Subpart 130.34(d) of EPA's Rules and Regulations states that in the event that a "Level B" plan as called for under Section 209 of P. L 92-500, "... has not been initiated, the State or designated areawide planning agency shall identify the appropriate constraints on water quality management which would be brought about by current and projected future (twenty year period) water demands." Water consumption and use may increase not only to support mineral processing, mineral transport (slurry pipelines, etc.), or other aspects of mine-related industrial activity per se, but also may increase to supply the consumptive needs of associated municipal and industrial growth. Recent studies having to do with the Yellowstone Basin, in the State of Montana, illustrate these kinds of issues involving water quantity/quality interrelationships.

If quantitative estimation of future pollutant loads is attempted, the effort should at least identify areas where substantial increases in pollutant loadings should be expected to result from anticipated mine-related industrial activities. Existing quantitative methods are more likely to yield general indications of where major loadings increases should be expected, than they are to yield very definitive information related to varying lesser degrees of future water quality degradation.

The complexities of dealing with generation, delivery and impact of pollutants from mine-related activities are no less intricate and involved for future operations than previously described for current operations in Chapter 3.0. Both point source and nonpoint source contributions may directly influence surface water and/or ground water quality, as may indirect hydologic imbalances and disturbances associated with mining and mine-related operations. Each stage and each phase of every type of mine-related industrial activity may exert a different and distinct influence on water quality. For example, the authors of a recent article entitled "Impact of Coal Handling on Water Quality"[1] stated that "Almost any step of coal mining, transport, storage, combustion, and disposal of refuse or residue will have an impact on the quality of surface and subsurface waters." Impacts during active development and construction may differ from those during routine operation, temporary inactivity, or long-term closedown. Some effects will be of short duration, while other more persistent effects may continue to influence water quality for decades or longer. Relative timing of different development events and rates of development will influence water quality impacts. The Idaho Phosphate EIS (1976) recognized this issue by stating: "If mining, and subsequent processing, proceed at a lesser rate than indicated by the mining plans as submitted, the environmental impacts will be less."

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[1] Metry, Amir A., and Weston, Roy F., "Impact of Coal Handling on Water Quality." Proceedings of the 21st Annual Technical Meeting of the Institute of Environmental Sciences, "Energy and the Environment. Anaheim, California. April 14-16, 1975.

Actual pollutant loadings will be dependent upon methods used in mining and associated mineral industrial operations and the control practices and preventive measures applied. The influence control practices and preventive measures have on future pollutant loadings from anticipated mine-related activities was also recognized in the Idaho Phosphate EIS (1976): "Absolute values of suspended-sediment concentrations are sensitive to many variables. Without precise knowledge of mitigating [control] measures, only order of magnitude changes can be estimated for values of suspended-sediment concentration . . . The Forest Service has estimated potential sediment yields as a result of the proposed mining . . . the qualitative estimates are presented here as indications of potential sediment yields. They are based upon the effectiveness of past reclamation measures."

Given the complexities and the unavoidable uncertainties, which are a part of any projection of impacts from future mine-related developments on water quality, quantitative estimates may be best used to support qualitative judgments of pollution potential.

Remaining tasks dealing with major new mine-related industrial development include:

WQM Task - Recognize future water pollution control needs.

WQM Task - Develop alternative control and management system strategies.

WQM Task - Estimate the effectiveness of alternative control strategies.

WQM Task - Select a new source control subplan.

WQM Task - Perform an environmental assessment of the chosen new source control subplan.

As was discussed earlier in regard to current source control subplans, alternative control strategies for both point sources and nonpoint sources are required. Denial of mine-related point source discharge permits or establishment of effluent limitations more stringent than those required under Section 301(b)(2) of P. L. 92-500 may be necessary when new mine-related point source discharges are projected on water quality limited segments or on high quality water or National resource water segments which are subject to strict antidegradation provisions.

Major new mine-related development planning will often require consideration of broader economic and social implications of control alternatives than were considered in routine new source planning. Most major new developments probably will have multi-state, regional, or even national implications. The possible effects of control alternatives on the mineral supply and demand situation, on user industries in both the local mining area or in other regions of the country, on the State or on regional energy supplies, on the Nation's balance of payments and world markets through influences on mineral commodity imports and exports, and even on national security, may require examination within the content of the control subplan selection process.

CHAPTER 7.0

CONTINUING MINE-RELATED WATER QUALITY MANAGEMENT AND WQM PLANNING

Part 130 of EPA's Rules and Regulations, entitled "Policies and Procedures for Continuing Planning Process," sets forth the general requirements for a continuing State and areawide water quality management and WQM planning process. The broad goal of this process is to assure that the necessary institutional arrangements and management programs are established to make and implement coordinated decisions for achievement of water quality goals and standards within each State.

7.1 Operational Mine-related Pollution Control and Water Quality Management

A number of the essential features of an effective water pollution control system and management process were covered in previous Chapters and are briefly described in the following discussion. These features include:

1. Ongoing evaluation of the effectiveness of the mine-related regulatory control system in achieving its water pollution control and beneficial water use protection objectives; including the effectiveness of various specific mine-related control practices, enforcement programs, preplanning permit approval procedures, and post-operations pollution prevention.
2. Ongoing examination of more effective and more advanced preventive measures and control practices, which may help to better prevent or control mine-related water pollution.
3. Prompt adoption and use of the most effective preventive measures and control practices (BMP's) currently available as improved

measures and practices are conceived, demonstrated and shown to be ready for practical application.

4. Integration of watershed planning and ground water recharge zone planning into pre-operations permit review procedures to recognize the cumulative impacts on water quality of all abandoned, current, and new mine-related sources. This would replace isolated permit review with an integrated, areawide water quality and beneficial use impact evaluation.
5. Continued refinement of pollution abatement program priorities for abandoned sources, better definition of source contributions and impacts, and identification of control mechanisms and opportunities.
6. Ongoing documentation of the effectiveness of accomplished and continuing abatement projects for abandoned sources.
7. Ongoing direction of the overall mine-related control program, including its enforcement aspects, priorities, and emphasis.
8. Effective integration and coordination of mine-related water pollution control for point sources (NPDES) and nonpoint sources (such as that coordination and integration now under way by the new U. S. D. I. Office of Surface Mining Reclamation and Enforcement and the U. S. Environmental Protection Agency to effectively control all water pollution, including point and nonpoint source contributions, from coal mining under Public Law 95-87).
9. Establishment of effective ties between mine-related control program(s) and other programs designed to deal with other pollution source categories, including silviculture, agriculture, construction, solid waste, etc.
10. Continued responsibility for recognition of new, or old, but increasingly serious, mine-related water pollution sources,

assessment of their water quality and beneficial use impacts, formulation of control alternatives, and implementation and operation of appropriately selected control systems. Pollution resulting from the consequences of mine-related hydrologic system disruptions and imbalances, increased mine-related industrial water consumption, pollutant contributions from future inactive or abandoned mineral industrial operations sites, and ground water pollution, should all be included within the scope of the continuing identification, assessment, and control selection and implementation process.

7.2 Continuing WQM Planning

The operational mine-related water quality management and pollution control process must be effectively linked to the whole continuing WQM planning process, required by P. L. 92-500, and EPA's subsequently issued Rules and Regulations.

Establishing proper linkages and coordinating mechanisms can be a difficult task if existing arrangements are poorly developed. However, this program element will be important in determining how well State water quality goals are achieved and beneficial water uses are protected by all the varied point and nonpoint source pollution control systems.

Part 130 of EPA's regulations requires that the State, and in some cases the areawide, continuing WQM planning process should provide for:

1. Public participation;
2. Intergovernmental input;
3. Coordination of State and areawide planning with one another and with all other related Federal, State, interstate, and local planning activities;

4. Preparation, adoption, and continuing revision of both State and areawide water quality management plans;
5. Establishment and implementation of regulatory and other than regulatory control programs;
6. Development, review, adoption, and periodic reexamination and revision (every three years) of Water Quality Standards;
7. Development, adoption, and implementation of a statewide policy on anti-degradation;
8. Review and certification of areawide WQM plans and annual revisions to such plans;
9. A State management program to oversee continuing areawide WQM planning efforts;
10. Establishment and continuing involvement of a policy advisory committee;
11. Coordination of permit actions of the National Pollutant Discharge Elimination System (NPDES) with current WQM plan provisions; and
12. Assumption of responsibility for achieving all the requirements of Section 208 of Public Law 92-500.

The overall water quality management requirement which the continuing management and WQM planning process must be designed to serve is stated in Section 201(c) of P. L. 92-500:

> "To the extent practicable, waste treatment management shall be on an areawide basis and provide control or treatment of all point and nonpoint sources of pollution, including in place or accumulated pollution sources."

WQM planning involves more than simply developing a static plan of defined components in a specified time period. Rather, the WQM program fulfills a broader purpose as stated in Section 208(f)(1) of P L. 92-500:

> "... of developing and operating a continuing [Statewide or] areawide waste treatment management planning process"

Initial State and areawide WQM plans represent the first outputs from operation of this continuing WQM planning process; a process which is intended to operate indefinitely into the future.

Annual requirements for outputs from each of the States to U.S. EPA, which are specifically called for by regulation under this continuing WQM planning process, include:

1. An annual review and revision, if necessary, of the continuing WQM planning process itself;
2. An annual revision and updating of both State and areawide WQM plans, which are intended to guide decision-making over at least a 20 year span of time in increments of 5 years;
3. An annual revision and preparation of a new five-year State Strategy which sets forth the State's major objectives, approaches, and priorities for preventing and controlling water pollution; and
4. An annual State program plan which establishes the immediate program objectives, identifies the resources committed to the State program for the coming year, and provides a mechanism for reporting progress toward achievement of program objectives.

APPENDIX A

EXAMPLE - MINE SITE HYDROLOGIC EXAMINATION

The hydrology of representative mine sites within major mine-related source subcategories should be examined and understood.

All surface water and ground water inputs, water, and point and nonpoint source pollutant transfers and outputs should be identified. Interrelationships among the various components should be defined, including the mechanisms of pollutant formation. Mine-related interruptions, disruptions, and imbalances to preexisting site hydrology, both temporary and permanent, should be recognized and understood.

Figures A-1 and A-2 illustrate a hypothetical active surface mining operation. Inputs of water to the mine site have been identified. The various modes and pathways of water and pollutant transfer from the mine site to receiving surface and ground waters have been diagrammed. Both point source and nonpoint source pathways of transfer have been included in the diagram.

Distinctions between point sources and nonpoint sources which are described here are intended only to reflect current working NPDES definitions; these source distinctions, as described, do not purport to reflect the ultimate limits of the U.S. Environmental Protection Agency's authority under the Water Pollution Control Act Amendments to define point sources of discharge from mining, and to promulgate and require compliance with appropriate effluent limitations. Collection and treatment may be a practical control alternative for some sources which are now defined in relation to NPDES as being nonpoint sources. Any control agency possessing sufficient independent regulatory control authority is free to establish effluent limitations and require treatment of any nonpoint source within

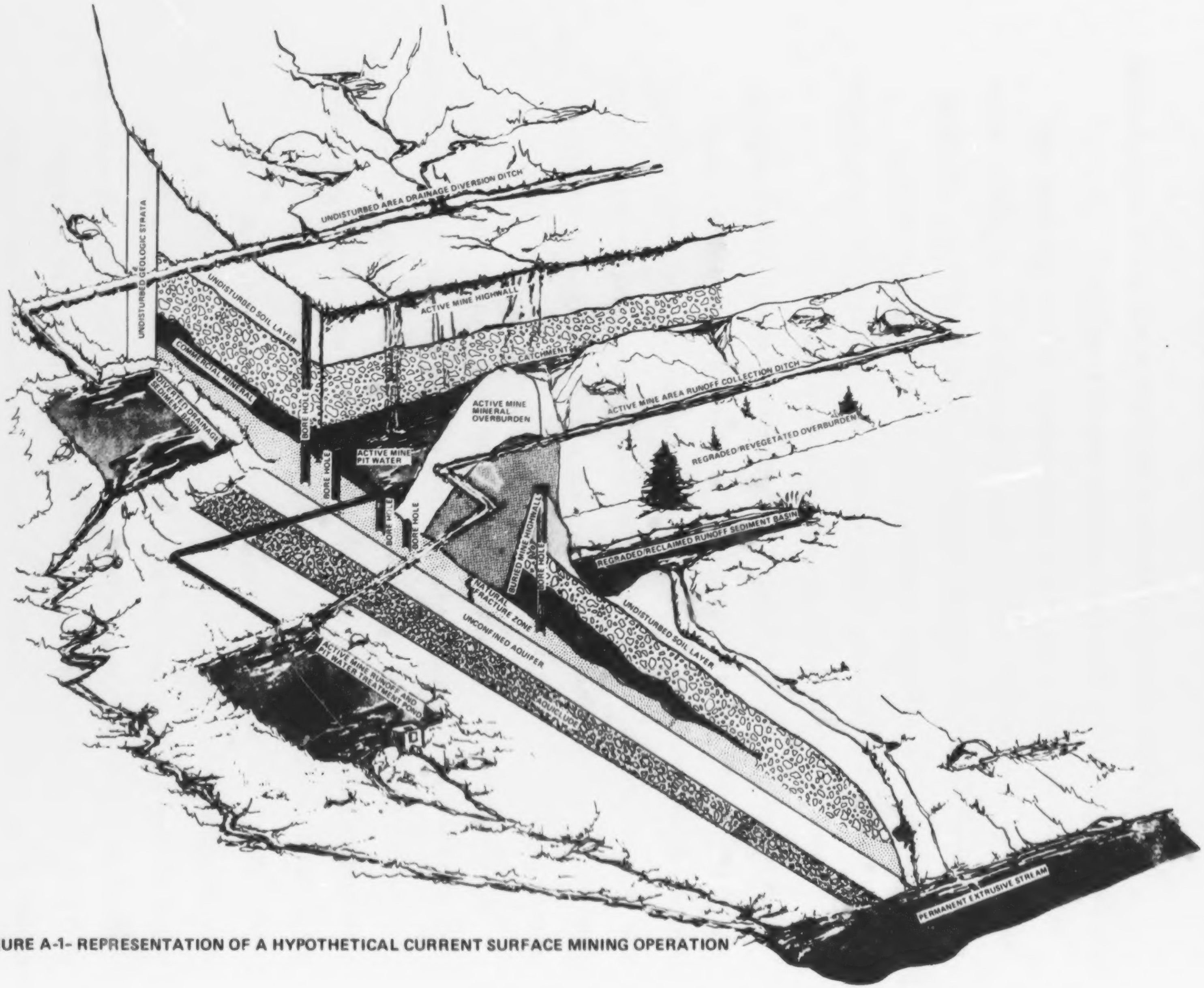
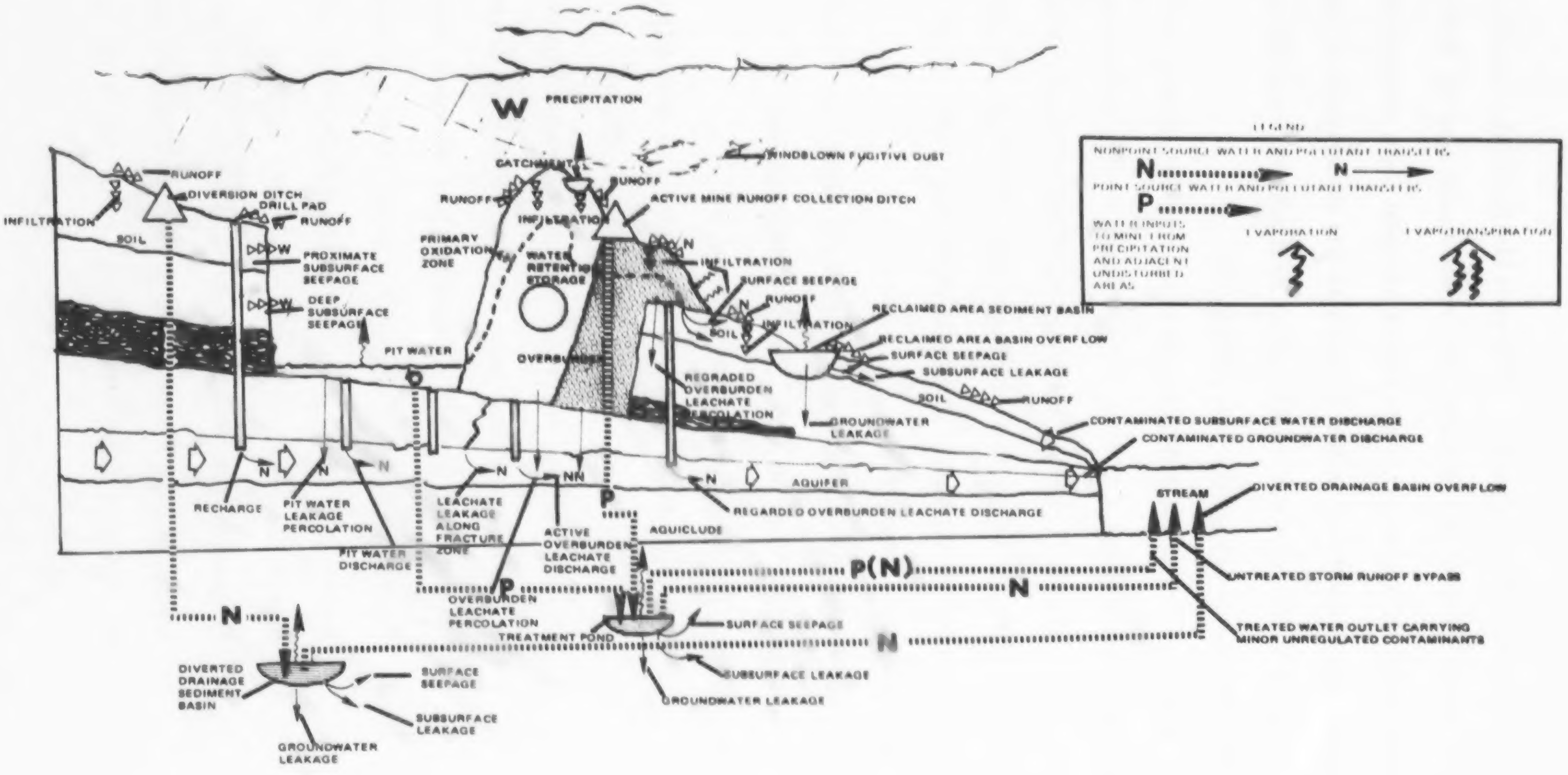

UNDISTURBED GEOLOGIC STRATA
UNDISTURBED AREA DRAINAGE DIVERSION DITCH
UNDISTURBED SOIL LAYER
ACTIVE MINE HIGHWALL
COMMERCIAL MINERAL
DIVERTED DRAINAGE SEDIMENT BASIN
BORE HOLE
CATCHMENT
ACTIVE MINE MINERAL OVERBURDEN
ACTIVE MINE AREA RUNOFF COLLECTION DITCH
ACTIVE MINE PIT WATER
BORE HOLE
BORE HOLE
BORE HOLE
REGRADED/REVEGETATED OVERBURDEN
BURIED MINE HIGHWALL
BORE HOLE
REGRADED/RECLAIMED RUNOFF SEDIMENT BASIN
NATURAL FRACTURE ZONE
UNCONFINED AQUIFER
UNDISTURBED SOIL LAYER
ACTIVE MINE RUNOFF AND PIT WATER TREATMENT POND
AQUICLUDE
PERMANENT EXTRUSIVE STREAM

FIGURE A-1- REPRESENTATION OF A HYPOTHETICAL CURRENT SURFACE MINING OPERATION

FIGURE A-2 - WATER INPUTS AND POINT AND NONPOINT SOURCE WATER AND POLLUTANT TRANSFER PATHWAYS FROM A HYPOTHETICAL CURRENT SURFACE MINING OPERATION


W PRECIPITATION
WINDBLOWN FUGITIVE DUST
LEGEND
NONPOINT SOURCE WATER AND POLLUTANT TRANSFERS
N
N
POINT SOURCE WATER AND POLLUTANT TRANSFERS
P
WATER INPUTS TO MINE FROM PRECIPITATION AND ADJACENT UNDISTURBED AREAS
EVAPORATION
EVAPOTRANSPIRATION
RUNOFF
DIVERSION DITCH
DRILL PAD
RUNOFF
INFILTRATION
SOIL
PROXIMATE SUBSURFACE SEEPAGE
DEEP SUBSURFACE SEEPAGE
W
PIT WATER
CATCHMENT
RUNOFF
RUNOFF
INFILTRATION
PRIMARY OXIDATION ZONE
WATER RETENTION STORAGE
OVERBURDEN
ACTIVE MINE RUNOFF COLLECTION DITCH
INFILTRATION
SURFACE SEEPAGE
RUNOFF
SOIL
INFILTRATION
REGRADED OVERBURDEN LEACHATE PERCOLATION
RECLAIMED AREA SEDIMENT BASIN
RECLAIMED AREA BASIN OVERFLOW
SURFACE SEEPAGE
SUBSURFACE LEAKAGE
SOIL
RUNOFF
GROUNDWATER LEAKAGE
CONTAMINATED SUBSURFACE WATER DISCHARGE
CONTAMINATED GROUNDWATER DISCHARGE
AQUIFER
STREAM
DIVERTED DRAINAGE BASIN OVERFLOW
RECHARGE
PIT WATER LEAKAGE PERCOLATION
PIT WATER DISCHARGE
LEACHATE LEAKAGE ALONG FRACTURE ZONE
ACTIVE OVERBURDEN LEACHATE DISCHARGE
OVERBURDEN LEACHATE PERCOLATION
AQUICLUDE
REGARDED OVERBURDEN LEACHATE DISCHARGE
NN
P
P(N)
N
N
UNTREATED STORM RUNOFF BYPASS
TREATED WATER OUTLET CARRYING MINOR UNREGULATED CONTAMINANTS
TREATMENT POND
SURFACE SEEPAGE
SUBSURFACE LEAKAGE
GROUNDWATER LEAKAGE
DIVERTED DRAINAGE SEDIMENT BASIN
SURFACE SEEPAGE
SUBSURFACE LEAKAGE
GROUNDWATER LEAKAGE

the limits of its own authority. Effluent limitations established for sources not now controlled under NPDES (sources which are by definition, nonpoint sources) may be made more or less stringent than limitations applicable to related point sources under NPDES at the discretion of the control agency, but any such independently established limitations must be consistent with meeting water quality goals and standards.

If, however, current NPDES point source definitions should be modified in the future to include a source which is currently defined as a nonpoint source, any effluent limitations which have been independently established by a control agency for such a source would subsequently have to be made at least as stringent as those limitations promulgated under NPDES for that new point source category.

Each aspect of the surface mine example shown in Figures A-1 and A-2 is discussed further in the following explanation:

A. Water Inputs To the Mine Site

1. Precipitation - timing, intensity and quantity of precipitation are a function of local climatic conditions.
2. Undisturbed area runoff - surface runoff from adjacent undisturbed areas may be intercepted by drainage diversion ditches and routed around the active mine site.
3. Subsurface water seepage - proximate and deeper subsurface water may enter the mine as seepage from adjacent areas above the level of the ground water table.
4. Ground water seepage - ground water seepage into the mine may occur in those cases where the mine pit or shaft extends below the ground water table. The mine pit of the surface mine shown

in Figure A-1 is above ground water level, so ground water seepage does not occur. The exploratory boreholes in Figure A-1 extend into the unconfined aquifer; if the aquifer were artesian rather than unconfined, such boreholes might represent channels of ground water flow into the mine, rather than pathways of drainage from it.

Once water has entered the active mine area, pit water accumulation, runoff, infiltration, evaporation, and water retention storage will take place internally. Chemical reactions also may occur. Minerals may oxidize or hydrolyze, and different minerals may react with one other, or produce intermediate products which cause further chemical reactions to occur elsewhere.

Wind action may be responsible for movement of windblown fugitive dust from the active mine area to adjacent reclaimed or undisturbed areas. These windblown materials may then contaminate surface runoff, proximate subsurface water, and/or ground water recharge.

B. Water Storage on the Mine Site

1. Water retention storage - water retention storage will normally take place within mineral overburden or other disturbed mineral materials on the mine site.
2. Mine water - water may accumulate in the pit of surface mines or within the workings of other mines. Normally such water

would be pumped out and discharged as a dewatering point source.

3. Catchments - small catchments of water may occur within mineral overburden or elsewhere within the workings of an active mine, increasing local evaportation, or infiltration, or both.
4. Pond and process water - Figure A-1 illustrates water storage in an active mine runoff and pit dewatering treatment pond. In other kinds of mineral industry operations, water may be retained within the active area for washing or processing, or within slurry, slime, or tailings settling basins, with or without discharge outlets.

Water and pollutant outputs from current mining operations include both point source discharges and nonpoint source transfer mechanisms. Figures A-1 and A-2 show two types of point source discharges and 10 nonpoint source water pollution transfer mechanisms and pathways for contaminated water movement.

C. Current Mining Point Source Discharges

1. Mine Dewatering Discharges - (a discrete point source) - accumulations of water in the mine pit or mine workings may have to be pumped out to allow normal mine operations to continue. Pumped mine dewatering discharges are point sources covered by NPDES permits and therefore are limited by NPDES effluent guidelines.

2. Collected Active Mine Area Runoff Discharges (a discrete point source following collection) - discharges from active mine area runoff collection ditches are point sources limited by NPDES effluent guidelines.

Active mine area runoff and pumped pit dewatering discharges may be channelled through the same or separate treatment ponds or systems prior to discharge into receiving waters. Such treatment ponds or systems must be designed to handle pit water and runoff volumes associated with a once in 10-year, 24-hour storm event. In case of a precipitation event which exceeds treatment system capacity, untreated excess storm runoff may be discharged to receiving waters without meeting effluent limitations.

D. Current Mining Nonpoint Sources

1. Regraded Area Runoff (a diffuse nonpoint source) - immediate surface runoff from surface mined areas which have been returned to final grade constitutes a nonpoint source under current NPDES definitions. Runoff following regrading throughout amendment application and revegetation is included in this category. Regraded area runoff may be sediment laden and should be channelled through a sediment basin or other treatment system prior to discharge into receiving waters. Regraded area runoff entering a sediment basin may also contain some quantities of regraded spoil leachate, spoil seepage, proximate subsurface water seepage, and ground water discharge.

2. Regraded Overburden Leachate (a diffuse nonpoint source) - infiltration of precipitation on regraded overburden may result in percolation of reclaimed overburden leachate into underlying, undisturbed soil or geologic strata. Such leachate may move downward as contaminated ground water recharge or laterally as proximate subsurface water. Contaminated subsurface water may emerge on the surface as polluted, proximate subsurface water seepage. Leachate may also be transferred downwards through unsealed boreholes to underlying strata.

3. Regraded Overburden Seepage (a diffuse nonpoint source) - precipitation which has infiltrated into regraded overburden may emerge at the bottom of regraded soil slopes as surface leachate seepage and, thereafter, become a constituent of regraded/reclaimed area surface runoff.

4. Active Mine Pit Water Leakage (a diffuse contribution from a permitted point source) accumulations of water in the mine pit or mine workings may slowly leak into underlying strata. Pit water may also move through unsealed bore holes into underlying strata.

5. Active Overburden Leachate (a diffuse contribution from a permitted point source) - precipitation which has infiltrated into active mineral overburden may emerge as leachage and percolate into underlying strata. Active overburden leachate may also be transferred downward into underlying strata through unsealed bore holes or

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through natural fractures and joints. Contaminants may also be transferred slowly from active mine pit water and saturated overburden by diffusion into adjacent strata.

6. Diverted Drainage Discharges (a non-permitted discrete discharge) - surface runoff from adjacent, undisturbed or regraded, reclaimed areas may be diverted around the active mine site. Drainage diversion ditches may erode and produce sediment laden, and less frequently, chemically contaminated, discharges requiring appropriate control. Control of diversion system pollution caused by the mining operation may be achieved either through use of practices and measures to prevent and reduce erosion (Best Management Practices) and/or by installing, operating and maintaining suitable treatment facilities, such as sediment basins. Erosion control practices include proper engineering design of the drainage diversion system, with gently sloping bank and ditch gradients capable of carrying expected peak runoff volumes, and use of such stabilization measures as mulching, vegetation, riprap or ditch linings. Chemically contaminated surface flows may also result in subsurface leakage and surface seepage of pollutants from unlined ditches and treatment ponds.

7. Uncontrolled Storm Overflow from Point Source Treatment Systems (an unregulated contribution from a discrete, permitted point source) - point source treatment and control systems installed under NPDES permit must be designed to adequately handle water volumes from active mine runoff and pit workings dewatering associated with a once in 10-year, 24-hour storm.

Excessive storm overflow from larger precipitation events may be discharged without meeting NPDES effluent limitations.

8. High Instantaneous Point Source Pollutant Concentrations (an unregulated contribution from a discrete, permitted point source) - concentrations of specific pollutants in point source discharges are not permitted to exceed specified 30 day average daily maximum values and single day average instantaneous maximum values. It is possible that high single instantaneous concentrations of regulated pollutants may be discharged over short periods without violating either single day average or 30-day average maximum effluent limitations.

9. Unregulated Contaminants in Point Source Discharges (an unregulated contribution from a discrete, permitted point source) - point source pollutants in discharges regulated by NPDES permit are selected for regulation based upon the "Best Practicable Control Technology Currently Available" (BPCTCA) and the "Best Available Technology Economically Achievable" (BATEA). Minor pollutants occurring in concentrations normally not high enough to have deleterious effects, which are partially controlled by removal of other major pollutants, or which are not feasible to control by treatment, are not included under effluent discharge limitations, even though concentrations at individual mine sites may rise above desirable levels.

NPDES effluent limitations for existing point sources in the acid or ferruginous coal mine-drainage category regulate pH, total suspended solids, and total manganese. (Final Rules, Federal Register, Vol. 42, No. 80, Page 213, April 26, 1977). Other pollutant parameters which may be present but are not specifically regulated in coal mining category discharges include dissolved iron, aluminum, nickel, zinc, fluoride, strontium, ammonia, sulfate and total dissolved solids.

Sediment basins to remove suspended solids from point source mine discharges are required by NPDES permits to handle 10-year, 24-hour stormwater runoff volumes, together with any dewatering or process water, without regard for the particle size distribution of influent suspended solids. Discharges carrying relatively large amounts of fine silt and clay sized particles could result if detention time is inadequate to cause fine grained sediments to settle. Fine suspended solids could be discharged from sediment basins without limitation, and technically without violating NPDES permit provisions, even during storm events smaller than the 10-year, 24-hour design storm. Discharges associated with snowmelt, rather than rainfall, may also be discharged without limitation.

10. Active Mine Runoff and Pit Workings Water Treatment Pond Leakage and Seepage (a diffuse contribution from a permitted point source) - unlined treatment ponds may leak contaminated water to underlying strata or may contribute surface seepage into adjacent surface waters or natural drainways leading to surface waters. Even when proper engineering design criteria

have been used in earthen dike or embankment construction, seeps and leaks may develop over time from a number of causes, including the action of burrowing animals such as nutria, muskrats, etc.

APPENDIX B

DISCUSSION OF WATER QUALITY IMPLICATIONS OF MINE-RELATED INDUSTRY ACTIONS

The nature and timing of mine-related actions will determine the interactions with pre-existing site conditions, the changes in those conditions, and the impacts on surface water and ground water quality and beneficial uses that will occur during and following the operations.

The interactions and the effects of industry actions on site conditions can be appreciated through:

1. An orderly classification of operations sequences, including a differentiation of rapidly developed versus gradually developed features, and functional versus nonfunctional operations and their resultant constructs.
2. An evaluation of the generation and delivery of each type of pollutant to receiving surface water and ground water. Such an evaluation would include both the adverse and the ameliorating water quality impacts associated with each stage of each separate operation and with each alternative operating method.
3. An examination of each action in temporal relation to climatic events, receiving water conditions and beneficial uses. The timing, duration and developmental stage of mine features are highly relevant to an understanding of the potential for causing pollution.

Table B-1 presents examples of site features from several, separate operations. Distinctions are made between functional and nonfunctional mine features, and rapidly developed and gradually developed mine features. Stages in the active life of each feature are described.

TABLE B-1 AN EXAMPLE CLASSIFICATION OF MINE-RELATED FUNCTIONAL AND NONFUNCTIONAL OPERATIONS SITE FEATURES BY STAGES

STAGES	NONFUNCTIONAL (Possible Functional Uses)				FUNCTIONAL		
	RAPID	GRADUAL			RAPID		GRADUAL
Development	Strip Mine Pit	Open Pit Mine	Deep Mine Workings	Well Emplacement	Mine Road	Sediment Basin	Tailings/Refuse Slime/Sludge Disposal Area
Stabilization	Regrading/ Revegetation	N.A.	N.A.	Casing	Drainage Control Installation	Slope Revegetation	Sediment Infiltration and Dust Control
Continuing Use	N.A.	(Mineral Extraction)	(Haulage/ Ventilation)	Oil or Gas Extraction	Hauling Mineral	Sediment Removal	Waste Disposal
Periodic Maintenance	Reseeding as Required	N.A.	Debris Removal	Cracked Casing Replacement	Grading Watering	Sediment Removal and Disposal	Control Measure Maintenance
Inactivation or Closure	N.A.	Flooding, or Partial Backfilling and Revegetation	Shaft Sealing	Well Sealing	Barrier Installation and Revegetation	Embankment Leveling Basin Backfilling Revegetation	Regrading, Seal Burying, and Revegetation

Rapidly developed nonfunctional features, such as strip mine pits, may be severe pollution sources for a short period only and then be stabilized by a reclamation process.

Gradually developed large open pit mines and deep mine workings expand slowly and may gradually become more significant sources of water pollution, especially ground water pollution, over time.

Rapidly developed functional mine features, such as mine haul roads, may be severe pollution sources for a brief period during construction, and then gradually stabilize with proper erosion and drainage control installation. Functional sources, however, fulfill some continuous operational use as part of the mine-related activity. Continuing use and maintenance of such functional mine features may result in additional pollution contributions throughout the term of their active life.

Table B-2 is an example of a past effort to estimate the environmental impacts of various methods of coal surface mining which was published in EPA 430/9-73-014 "Methods for Identifying and Evaluating the Nature and Extent of Nonpoint Sources of Pollutants." Water quality impacts expressed in Table B-2 represent judgments of pollution potential supported by both field experience in the coal mining industry and appreciation for the sequence of physical conditions produced at the mine site during application of each different mining method. Steep mountain contour mining accomplished with no placement of spoils on the downslope is shown to have a very modest surface water pollution impact potential, while conventional contour stripping is shown to have a severe adverse impact potential.

Table B-3 represents a past effort to estimate the environmental effects of each of the discrete activities and the stages which are involved in carrying out a coal surface mining and reclamation operation. This

TABLE B-2

ESTIMATED ENVIRONMENTAL EFFECTS OF COAL SURFACE MINING

(Scale for severity of environmental indicators:[a] 3 = Severe adverse impact; 0 = Negligible adverse impact)

Mining Technique[b]	Water			Air Pollution (Dust)	Land Use (Adjacent Land Impact and Precluded Land Use)	Health and Safety (Landslides and Flooding)	Wildlife Habitat and Disruption	Aesthetics (Highwall and Vegetation)	Total[c]
	Surface Pollution	Groundwater	Changed Water Courses						
Area Mining:									
Without reclamation	1-2	0-1	1-3	2-3	2-3	0	1-2	2-3	9-16
With reclamation[d]	0-1	0-1	0-1	1	0	0	0	0	1-4
Contour mining (spoils on downslope):									
Conventional contour strip	3	0-1	2-3	2-3	3	3	1-3	3	17-22
Contour strip with spoils shaping	1-3	0	2-3	2-3	2-3	1-3	1-2	2-3	11-20
Contour strip with terrace backfilling	1-2	0	0-2	1-2	1-2	1-2	1-2	0-1	4-13
Contour strip with contour backfilling	1	0	0-1	1-2	0-1	0-1	1	1	3-8
Augering from narrow bench	1-3	1-3	0-1	0-1	1-2	0-1	0-1	1	3-12
Contour mining (no spoils on downslope):									
Modified block cut	1	0	0	1	0	0	0-1	0-1	2-4
Long wall surface	0-1	1-2	0	0-1	0-1	0	0	0	1-5
Augering with backfilling	0-1	1-2	0	0-1	0	0	0	0	1-4

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a/ Indicators are for both temporary and pervasive impacts.

b/ Head of hollow fill technique is not rated here because its environmental effects also depend on the technique(s) for which it serves as a supplemental method for spoil disposal.

c/ Aggregating environmental parameters into a single index is difficult and often involves value judgments with respect to relative importance of the factors involved. These totals assume equal weighting of environmental impacts. Use of other weights could alter the ranking of the techniques.

d/ This ranking is for area mining in the eastern and central coal regions with adequate rainfall for vegetation. Area mining in the far west may well be unacceptable unless vegetation can be reestablished.

TABLE B-3

RATING OF ENVIRONMENTAL EFFECTS OF DISCRETE COAL SURFACE MINING AND RECLAMATION OPERATIONS

	Environmental Component															
	Physical-Chemical											Biological		Cultural		
	Landslides	Slumping	Highwall	Erosion	Sediment Transport	Chemical Pollution	Changed Water Courses	Flooding	Groundwater Disruption	Dust	Noise	Ground Cover Destruction	Wildlife Pattern Disruption	Precluded Land Use	Adjacent Land Use	Aesthetic Deterioration
Surface Mining Operation																
1. Access road cut and use	+	+	0	+	+	+	+	0	0	+	0	+	0	0	+	0
2. Drilling and blasting	+	+	+	0	0	0	+	0	+	+	+	+	+	+	+	+
3. Scalping	0	0	0	+	+	0	0	+	0	+	0	+	+	0	0	+
4. Overburden removal and placement	+	+	+	+	+	+	+	+	+	+	0	+	+	+	+	+
5. Coal removal	0	0	+	+	+	+	0	0	0	+	0	0	0	0	0	0
Net Environmental Effect of Surface Mining Operation	3+	3+	3+	4+	4+	3+	3+	2+	2+	5+	1+	4+	3+	2+	3+	3+
Reclamation Operation																
6. Spoil rehandling and grading	-	-	-	-	-	-	-	-	0	+	0	0	-	0	-	-
7. Revegetation	-	-	0	-	-	0	0	-	0	-	0	-	-	-	-	-
8. Drainage controls	-	-	0	-	-	-	-	-	-	-	0	-	0	0	-	0
9. Sediment basin	0	0	0	0	-	0	0	-	0	0	0	0	0	0	-	0
Net Environmental Effect of Reclamation Operation	3-	3-	1-	3-	4-	2-	2-	4-	1-	1-	0	2-	2-	1-	4-	2-
Net Environmental Effect of Surface Mining And Reclamation Operation	0	0	2+	1+	0	1+	1+	2-	1+	4+	1+	2+	1+	1+	1-	1+

+ Adverse Environmental Impacts Aggravated
0 Negligible Environmental Impacts
- Adverse Environmental Impacts Corrected

example illustrates one approach which may be useful in identifying those areas where preventive measures or control practices need to be applied.

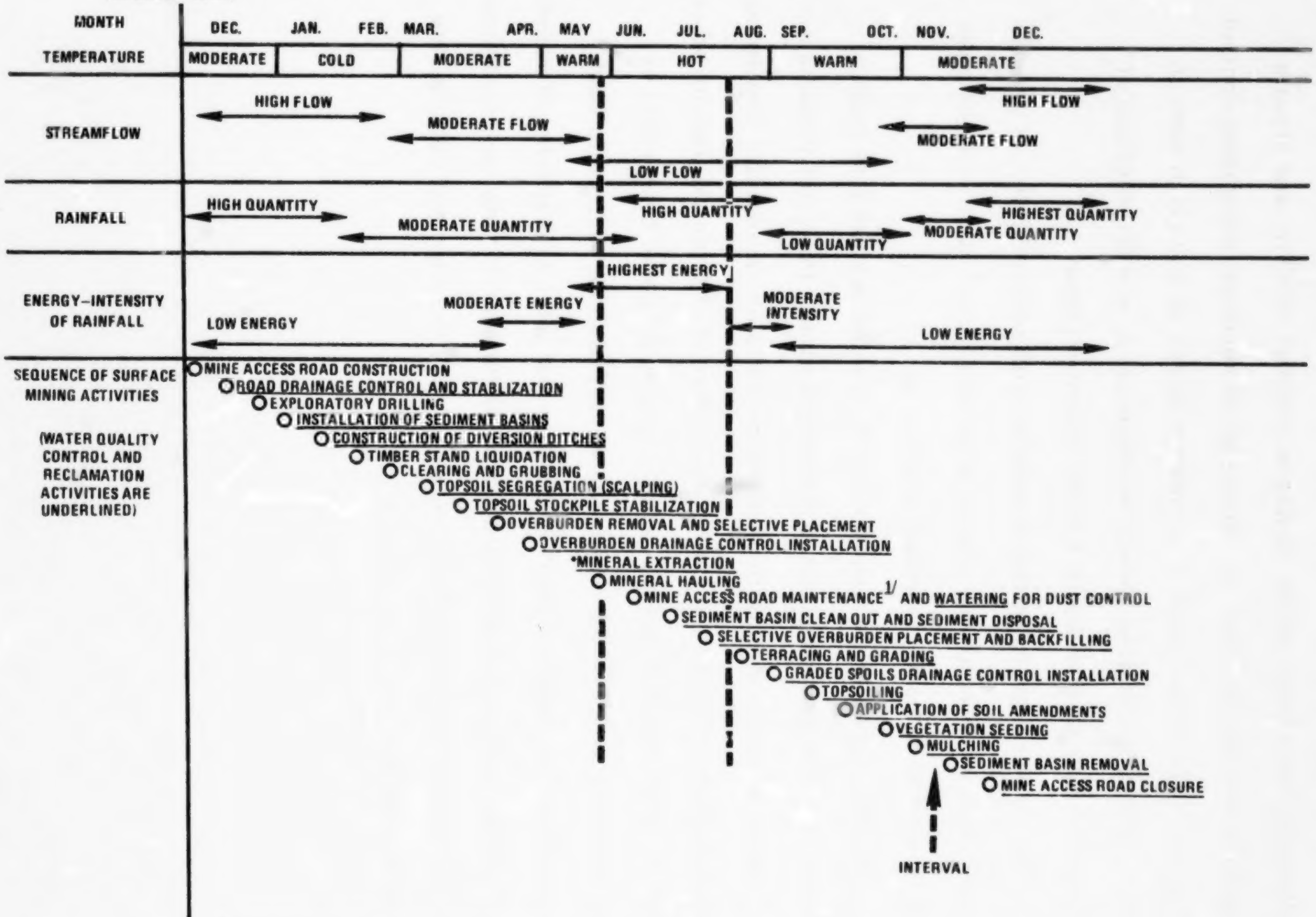
Mine-related operations and actions, especially those involving rapid changes and developments, should be viewed in relation to the temporal variation of climatic events and the condition of receiving waters (including aquatic life sensitivity). Figure B-1 is a hypothetical illustration of the relationships in timing among amount of rainfall, quanity of streamflow, rainfall energy-intensity (erosive force), and a typical sequence of activities during a one year period of a surface mining operation. Although the situation described is hypothetical, it may correspond to conditions found in the Southern Appalachian Region.

Periods of highest streamflow may not necessarily coincide with periods of highest rainfall because of the effect of temperature and evapotranspiration, as well as the influence of the condition of vegetation on infiltration/runoff relationships.

Periods of highest rainfall energy/intensity may not coincide with periods of highest rainfall quantity. Severe thunder storms may occur during periods of moderate rainfall. Slower more gentle rains occurring at other times of the year may produce larger total quantities of precipitation.

The timing of mine-related activities can sometimes be adjusted to avoid creation of potentially severe pollution sources. Regulation of the intensity as well as the timing of certain activities during critical periods may help to better control or prevent adverse water quality impacts; for example, unpaved and unsurfaced mine haul road use may be reduced during bad weather to prevent deep rutting and resultant increased erosion as an alternative to construction of an all weather road surface. Even under circumstances when adjustment of activity schedules may not be

FIGURE B-1 - TYPICAL SEQUENCE OF ACTIVITIES ASSOCIATED WITH CONDUCT OF A SURFACE MINING OPERATION SHOWN IN RELATION TO LOCAL TEMPERATURE, LOCAL STREAMFLOW, LOCAL RAINFALL QUANTITY AND LOCAL RAINFALL ENERGY–INTENSITY (Erosive Force)


MONTH
DEC.
JAN.
FEB.
MAR.
APR.
MAY
JUN.
JUL.
AUG.
SEP.
OCT.
NOV.
DEC.
TEMPERATURE
MODERATE
COLD
MODERATE
WARM
HOT
WARM
MODERATE
STREAMFLOW
HIGH FLOW
MODERATE FLOW
LOW FLOW
MODERATE FLOW
HIGH FLOW
RAINFALL
HIGH QUANTITY
MODERATE QUANTITY
HIGH QUANTITY
LOW QUANTITY
MODERATE QUANTITY
HIGHEST QUANTITY
ENERGY–INTENSITY OF RAINFALL
LOW ENERGY
MODERATE ENERGY
HIGHEST ENERGY
MODERATE INTENSITY
LOW ENERGY
SEQUENCE OF SURFACE MINING ACTIVITIES
(WATER QUALITY CONTROL AND RECLAMATION ACTIVITIES ARE UNDERLINED)
MINE ACCESS ROAD CONSTRUCTION
ROAD DRAINAGE CONTROL AND STABLIZATION
EXPLORATORY DRILLING
INSTALLATION OF SEDIMENT BASINS
CONSTRUCTION OF DIVERSION DITCHES
TIMBER STAND LIQUIDATION
CLEARING AND GRUBBING
TOPSOIL SEGREGATION (SCALPING)
TOPSOIL STOCKPILE STABILIZATION
OVERBURDEN REMOVAL AND SELECTIVE PLACEMENT
OVERBURDEN DRAINAGE CONTROL INSTALLATION
*MINERAL EXTRACTION
MINERAL HAULING
MINE ACCESS ROAD MAINTENANCE 1/ AND WATERING FOR DUST CONTROL
SEDIMENT BASIN CLEAN OUT AND SEDIMENT DISPOSAL
SELECTIVE OVERBURDEN PLACEMENT AND BACKFILLING
TERRACING AND GRADING
GRADED SPOILS DRAINAGE CONTROL INSTALLATION
TOPSOILING
APPLICATION OF SOIL AMENDMENTS
VEGETATION SEEDING
MULCHING
SEDIMENT BASIN REMOVAL
MINE ACCESS ROAD CLOSURE
INTERVAL

1/ ROAD MAINTENANCE MAY BE CONSIDERED TO BE BOTH A PRODUCTION AND A WATER QUALITY CONTROL FUNCTION.

practicable, knowledge of the timing of critical climatic and stream conditions will aid in planning and design of adequate mitigating control measures. The area exposed to erosive forces at any given time in surface mining operations should be minimized, and the duration of exposure should also be limited to the extent feasible.

The time variation of the sensitivity and susceptability of aquatic life and other beneficial water uses to impacts from mine-related pollutants is also an important consideration.

In some areas of the country, wind erosion resulting in fugitive dust emissions may contribute to water pollution. Pollutant impacts are likely to be of greatest significance where toxic or radioactive contaminants are involved (as may be the case with fugitive dust from tailings or other mineral waste disposal areas). Particulate matter can be carried by winds directly to receiving waters; dust may also be carried to land areas adjacent to mine-related operations and later transported in runoff to receiving waters. Accumulations of dust on winter snow cover adjacent to mine-related industrial sites can contribute to water pollution during the spring thaw.

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